QUALITY-BASED SUPPLY MANAGEMENT INDICATORS

THESIS

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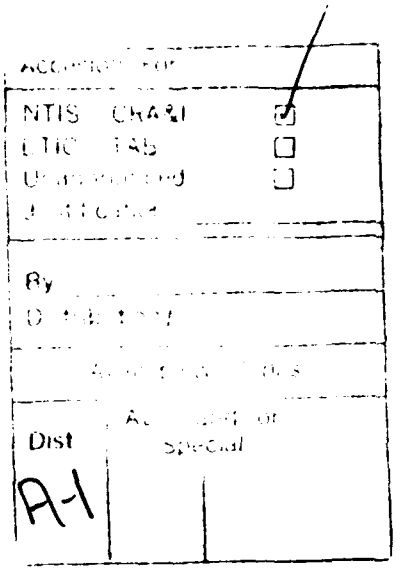

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THESIS

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Master of Science in Logistics Management

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Abstract

The purpose of this thesis was to determine if current supply management indicators provide supply managers with quality measurement tools. This research developed the Quality-Based Metrics Framework, consisting of customer focus and continuous process improvement with underlying supporting elements of time and cost.

A literature review determined an appropriate framework for improving logistics indicators. Interviews with supply analysts and a review of pertinent publications identified the most commonly used supply management indicators. A focus group of highly experienced senior supply officers determined the usefulness of currently used indicators in terms of the framework. Using the input from the focus group, the authors developed a revised list of metrics which strongly reflected the elements of the framework.

The revised metrics were evaluated by the same focus group and found to be more useful in terms of the framework. These results were validated by surveying a sample of senior supply managers throughout the Air Force. The results indicate that the current supply indicators could be improved to provide managers with better quality management tools.

QUALITY BASED SUPPLY MANAGEMENT INDICATORS

I. Introduction

Background

General. The United States, along with the rest of the world, has seen tremendous change in the last decade. This change includes the reunification of Germany, the appearance of new countries as a result of the break-up of the USSR, and the end of the Cold War. Americans are faced with a different world today, and the uncertainty that follows such dramatic change.

As a result of the changing world and the end of the Cold War Era, the perceived need for a large military has dramatically decreased. Now that the military is no longer viewed as such a vital component to the national interest as compared to the economy, the American people have asked for the "peace dividend." This peace dividend equates to taking the money that was previously spent on the military and funneling it to domestic and social issues which are perceived as being in more desperate need of funds.

The population of military personnel has decreased from a peak of 2,174,000 in 1987 to 1,886,000 in 1992, reflecting the changing world and satisfying the wishes of Americans to

spend less on defense (AF Magazine, 1993:48). It is projected to decrease even further.

Along with a reduction in personnel, there is an ongoing reduction in the total number of bases and weapon systems. For the United States Air Force (USAF), the obvious reduction is in the number of bases and the total number of aircraft. Since fiscal year 1989, the number of major installations worldwide has dropped from 141 to 124. The total number of aircraft in the active duty Air Force inventory was 6724 as of 30 September 1990, from a previous peak of 7299 as of September 1985 (AF Magazine, 1992:24). These dramatic cuts require an efficient logistics system in order to maintain national defense.

Standard Base Supply System. Base supply plays an important role in the overall logistics functions of the Air Force, as can be seen in the following passages:

> Because ... a ready supply of dependable spare parts are essential to a strong air defense ... reliable products and prompt services is today an inseparable component of modern Air Force logistics.
> (Brownlee, 1989:4)

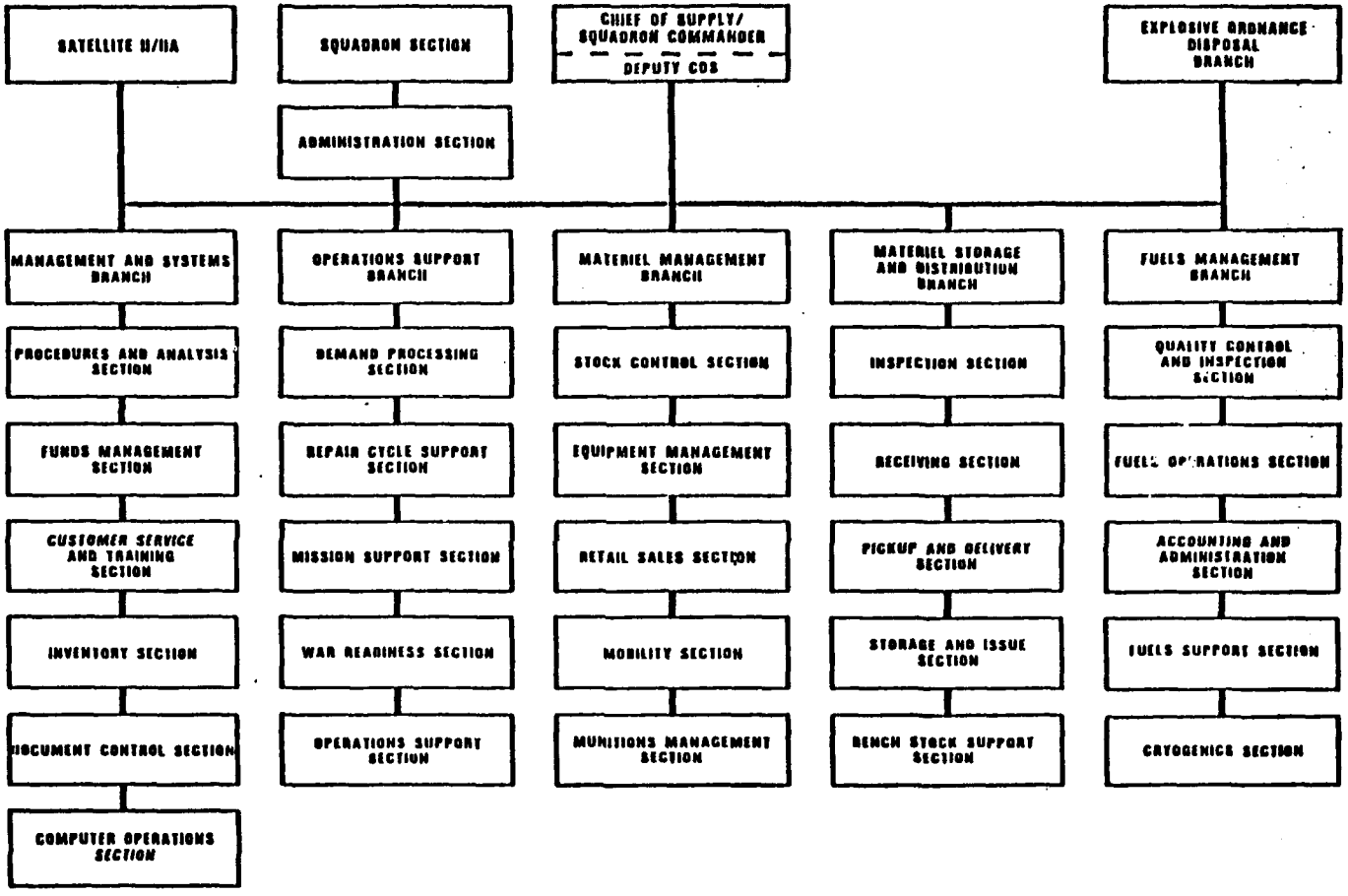
> Aircraft grounded for lack of parts or consumables represent, for the period they are out of service, as much loss to combat capability as aircraft destroyed by enemy action. (DAF, March 1992:255)

The USAF uses what is known as the Standard Base Supply System (SBSS) to support the maintenance and operations of all aircraft at the wing level. The SBSS is defined as an accounting system consisting of standardized computer

equipment, programs, procedures, and supply policy to provide base activities with their supply needs and accounts for supplies, equipment, fuel, munitions, and clothing (DAF, July 1992:Ch 1, 7).

A Chief of Supply (COS) is charged with operating the SBSS. The COS is responsible to the wing commander for an effective and efficient base supply operation. A typical supply squadron consists of approximately 200 men and women, comprised of both military and civilian personnel. The squadron is normally broken down to five smaller sections, referred to as flights, which are managed by supply officers (flight chief) and senior NCOs (flight superintendent). Within each flight are subsections, referred to as sections (see Figure 1). The Chief of Supply relies on the flight chiefs and superintendents to make daily decisions which affect the supply account.

The Supply Management Report (M-32) is the most comprehensive management report available to supply managers and the primary source of management indicators used by base-level supply managers (DAF, July 1992:Ch 5, 395). The M-32 is published at the end of every month in a standard format and shows the aggregated monthly status for various supply functions.



CHIEF OF SUPPLY ORGANIZATION CHART

Figure 1. Base Supply Organizational Chart

Total Quality Management. Total Quality Management (TQM) is the generic term that was adopted by American industry and government for quality management programs. TQM evolved in America but became famous through effective implementation in Japan (Krone, 1990:35). There is no simple definition of Total Quality Management (TQM), and very few people fully understand the philosophy well enough to implement it. "Because of the lack of full understanding of what TQM is and the absence of clearly specified objectives, success has been sporadic and progress across large organizations very slow" (Emmelhainz, 1991:35). According to Deming, a leader in TQM, there are 14 obligations of top management to eliminate obstacles that hinder quality improvements, many of which were established by management. Following are some of the management obligations that apply to continuous process improvement:

- Constantly improve production
- Create constancy of purpose toward improvement
- Replace quotas and eliminate management by objective
- Eliminate slogans, exhortations, and targets
- Cease dependence on inspection to achieve quality
- Institute leadership (Deming, 1986:23-24)

According to a DOD policy, the hallmark of the TQM process is continuous improvement (DOD, 1990:2). Quality improvement and process measurement must have objectives. First, the customers have to be identified and their requirements made known in order to consistently meet their needs and expectations (DOD, 1990:4). According to Saylor: "Customer is everyone affected by the product or service"

(Saylor, 1990:20). Once the customer is identified, performance measures need to be established to support the concept of continuous improvement. The Federal Total Quality Management Handbook describes quality this way:

> Some people are confused by the term quality, because it has many different meanings depending on the context. When it is referred to as part of the TQM effort in the federal government, quality is defined as "meeting the customer's requirements, needs, and expectations, the first time and every time." Who determines what quality is? Our customers, inside and outside each organization. Congress, which represents the public is included. Customer satisfaction is paramount. (Hyde, 1990-91:16)

The message behind this definition is that any concept of quality must be customer focused.

TQM in Base Supply. The concept of continuous improvement is especially salient in supply management due to the current supply measurement system. While the primary emphasis is placed on supporting the operational mission through stocking and requisitioning aircraft spare parts, supply managers are measured against a different set of standards during the monthly analysis program called the Chief of Supply "How Goes It" (Greer and Moon, 1981:32). Because the main customer of base supply is the maintenance organization, the standards should be focused on how well they are supporting the main customer.

During the "How Goes It" session, current indicators are compared against Major Command (MAJCOM) imposed targets. The potential danger with this method of measurement is that

if the various functions are meeting or exceeding the stated goal, no further research is required. Only when a stated goal is not met is research conducted. This method seems to go against three of Deming's obligations of top management: Eliminate management by objective; eliminate targets; and inspecting after the fact, rather than continuously striving to improve.

Another obligation of top management is that managers must take an active leadership role in improving the quality within the organization. Despite the fact that there is a tool to keep track of the supply account on a daily basis, due to the sheer volume of information, most managers are content to wait until the M-32 is published at the end of the month (LeSage, 1989:8). By waiting until the end of the month, supply managers are taking a reactive rather than a proactive leadership role.

The format of the M-32 has remained unchanged since the Air Force began implementing TQM and may not meet the current criteria for an effective measurement as outlined in Total Quality Management philosophy. Incorporating base supply management reports, specifically the M-32, into the Quality Air Force (QAF) philosophy may require restructuring the M-32 to enhance the concept of continuous process improvement (DOD, 1990:iii).

Specific Problem

The management indicators that supply managers are using may not be consistent with the TQM philosophy.

Objective Statement

The objective of this research is to determine which management indicators should be used in order to provide supply managers with quality measurement tools.

Investigative Questions

The questions that must be answered in order to solve this specific problem are:

1. According to the TQM philosophy, what are the appropriate characteristics which management indicators should possess in order to assess the performance of base supply?
2. What are the most commonly used supply management indicators?
3. In terms of TQM, how useful are these indicators to base supply officers?
4. Can these supply indicators be modified so that they are more in-line with the TQM philosophy?

Scope

The scope of this thesis will be limited to base-level supply accounts, and information will be gathered only from supply officers and managers with at least ten years of base-level supply experience. The emphasis will be on the M-32 (Supply Management Report) and the role it will play in the new Air Force style of a Quality Air Force. This thesis

will not attempt to cover indicators from a systems perspective, even though improvements to the current system might possibly be made by linking the measurement systems of the several echelons.

Justification

This research is required for three reasons. First, although there is a plethora of research on quality processes in manufacturing organizations, there is little information on what specific quality measures to use in logistics areas. Second, the dramatic budget cuts over the past few years require the military to operate more like a business and maximize effectiveness while minimizing costs. Finally, the Air Force is implementing quality programs service-wide, yet logisticians are still using the same management indicators that they have used for many years.

Summary

The Air Force is undergoing major reductions in the face of dramatic global political changes. The emphasis is being placed on the Air Force to operate more effectively and efficiently. In order to achieve this goal, the Air Force has adopted the TQM philosophy. The SBSS is an integral part of overall Air Force operations. However, its measurement system has remained unchanged since the adoption of the TQM philosophy. As the primary management measurement report for base supply, the M-32 does not appear

to be providing top management with measures consistent with the TQM philosophy.

Overview

This chapter introduced some of the factors which are driving the need to improve current base supply management indicators. Chapter two provides an in-depth review of TQM in the Department of Defense and what constitutes a good supply indicator in terms of TQM philosophy. Chapter three focuses on the methodology used to accomplish the research. The fourth chapter presents the findings and results of the research. Chapter five will present conclusions and recommendations in the area of continuous improvement for base supply management.

II. Literature Review

Introduction

Key Terms. The purpose of this review is to analyze current literature relating to quality improvement and the management indicators used in measuring quality levels. This review will determine what constitutes a good measure, with an emphasis on continuous process improvement and customer focus based on TQM philosophy. It will focus on measures within the field of logistics.

The terms measures, management indicators, and indicators all have the same meaning and will be used interchangeably throughout this thesis. These terms should be distinguished from the term metrics.

> Metrics are nothing more than meaningful measures. For a measure to be meaningful, however, it must present data that allow us to take action. It must be customer oriented and support the meeting of our organizational goals and objectives. Metrics foster process understanding and motivate action to continually improve the way we do business. This is distinguished from measurement, in that, measurement does not necessarily result in process improvement. Good metrics always will. (AFSC, 1991:1-1)

Quality improvement is known by many titles. Quality Control, Total Quality Improvement, Total Quality Control, and Total Quality Management are all familiar terms for the same fundamental philosophy. This philosophy, as it applies to the Department of Defense, is derived mainly from the writings of Dr. W. Edwards Deming and Dr. J. M. Juran (DOD, 1988:1). Total Quality Management (TQM) is defined as:

> ... both a philosophy and a set of guiding principles that represent the foundation of a **continuously improving organization**. TQM is the application of **quantitative methods** and human resources to improve the material and services supplied to an organization, all the **processes within** an organization, and **the degree to which the needs of the customer are met**, now and in the future. [emphasis added](OASD, 1989:1)

Based upon this definition, TQM can be described as continuously enhancing customer service by improving internal processes through quantitative methods. One item that TQM should address specifically is what measurement system should be developed to support the quality program (Hyde, 1990-91:17).

Quality Measurement. The importance of quality measurement is reflected in the following passage:

> You cannot manage what you cannot measure. You cannot measure what you cannot operationally define. You cannot operationally define what you do not understand...You will not succeed if you do not manage. (VPC, 1989:74)

There are two kinds of change that the Air Force is currently undergoing. The first type of change is something that we have no control over, the top-down mandated reduction in the size of the military due to the public perception of increased world stability. The second type of change is internal and is caused by our desire to become a Quality Air Force (McPeak, 1992). These two changes are providing the impetus for Air Force personnel to do things smarter. Because of these changes, the Air Force needs to

review its current measurement systems to make sure that measures are consistent with TQM goals.

The Wang corporation recently underwent a change, less drastic than the one faced by the Air Force today, when they introduced just-in-time manufacturing methods. This change forced them to alter their entire performance measurement system. Wang developed a new measurement approach, called Strategic Measurement Analysis & Reporting Technique (SMART). SMART's goal is to integrate both financial and nonfinancial reporting, to link operational goals to strategic goals, and to concentrate the measurement system design on satisfying customer needs and fostering constant evolution (Dixon and others, 1990:52).

Implementation of the SMART system resulted in some indicators being deleted and some being modified. The revised indicators now meet the criteria of metrics.

> Approximately 40 percent of the existing measures were discarded, including purchased price variance, labor productivity, and virtually all of the standard cost accounting variances for operating feedback.
>
> Examples of new metrics are new measures of inventory turns, plug and play rates, material availability, waste rates, and process times.
> (Dixon and others, 1990:55)

The TQM concepts of satisfying customer needs and fostering continuous improvement are discussed in the next section.

Framework

The framework for this discussion consists of customer focus and continuous process improvement as they relate to quality based indicators. The quality measurement section provided a brief overview of why Air Force supply managers must reevaluate the current measurement system by focusing on customer needs and fostering continuous improvement.

The literature review revealed that two key areas of TQM philosophy, customer focus and continuous process improvement, constitute a basic guideline for a quality measurement system. These two areas coincide with those that Wang Corporation focused on when implementing their new measurement system. While TQM literature emphasizes customer focus and continuous process improvement, business and application-oriented literature focuses more on tangible and practical issues such as the "bottom line," which can be judged and measured by time and cost factors. Thus, the two key areas of customer focus and continuous process improvement are supported by both time and cost factors. An example of how one aspect of the framework can be analyzed by time and cost factors is shown in the case of Northern Telecom Inc., where an emphasis in reduction of production time resulted in lower inventory and overhead cost and an improvement in quality (Merrills, 1989:109).

The framework described above will henceforth be referred to as the Quality-Based Metrics Framework.

Customer Focus. One of the basic tenets of TQM is complete customer focus (Emmelhainz, 1991:35; Hyde, 1990-91:16-17). All measures and processes must be customer focused, whether the customers are internal or external customers. Research shows that, within logistics, quality programs are most fully implemented in the area of customer service (Read and Miller, 1991:34). Improved customer service is a major goal of TQM. It is therefore logical to place initial emphasis on customer service. By doing this, an organization can show immediate, short-term results from its TQM efforts through improved customer satisfaction.

In logistics, customer service level is expressed as the percentage of demand filled within a specified time period after receipt of the customer's order (Tersine, 1988:211). Achieving the required customer service level requires the active participation of all facets of the organization (Motiska and Shilliff, 1988:27). Many logistics functions, such as transportation, storage, receiving, inventory management, forecasting, purchasing, and planning, indirectly contribute to the overall customer service level. Without improvements in these related areas, customer service improvement will be limited.

A question related to the strategic focus of TQM is whether or not the quality performance measures used by organizations actually reflect customer priorities. For example, the percentage of on-time shipments received by the supplier is not an indicator which concerns the customer of

the supplier. The customer only measures whether or not his or her shipment arrives on time from the supplier. What is important to the customer is what logisticians should measure (Trunick and Richardson, 1990:19).

Customer focus is one important aspect of a good indicator. Customer support is also a determinant of the effectiveness of a supply organization. Therefore, one of the characteristics that supply management indicators should possess is customer focus. This focus should be directed towards processes to improve overall service and aimed at both internal and external customers.

Continuous Process Improvement. Another basic tenet of TQM is continuous process improvement (Emmelhainz, 1991:35-36). Process improvement can be described as breaking down all logistics functions into well-defined activities and then improving lower level activities that link to the critical logistics goals. (Beischel and Smith, 1991:25-26) "Performance measurement is built into the processes of identifying and overcoming problems that lie at the heart of continuous improvement" (Hall and others, 1991:v).

Continuous process improvement relies on building quality into a product or service, not inspecting it in (Prowse, 1990:5). This entails looking in detail at the steps involved in a process rather than just the outcome of the procedures. The Federal Quality Institute identified measurement and analysis of processes as key factors in

determining successful quality efforts (Hyde, 1990-91:17). Indicators show how efficiently an organization is achieving its goals and identify potential areas for improvement.

Looking at continuous process improvement strengthens the question as to whether customer service is the best indicator of quality improvement. Customer service is the *product* of all logistics processes. The logistics processes are the means to achieving the desired level of customer service.

Measures that are taken at the end of processes are primarily of use to quality planners. The people responsible for improving the operations, on the other hand, need measures taken during operations (Juran, 1988:97). Supply management indicators should be process oriented rather than post-operations summaries if they are to be used to improve quality of the supply processes. An example of a process-oriented measure is the daily reject listing which tracks the number of wrong inputs into the base supply system and provides immediate feedback to the operator.

Supporting Elements. Both time and cost factors are integral supporting elements for measuring the level of customer focus and continuous process improvement. Customers naturally want their product or service as soon as possible at the lowest price. In the past, cost was not a major issue within the DOD setting. However, due to the top-down changes in cost accounting, cost factors are having

an increasingly greater impact on Air Force operations and should be considered when measuring processes.

On the surface, the distinction between time and cost is obvious, speed versus money. However, in service organizations such as base supply, this distinction can become blurred. An example of this would be backorder costs. Backorder costs relate to cost in that they are the dollar values associated with having to place a backorder for an item that is needed but is not in stock. They relate to time in that backorders cause customers to wait for needed assets. Because customers associate service with the amount it takes to receive their goods, supply often must expedite shipments to please customers. This increases ordering and transportation costs.

Time. In a society where instant gratification is taken for granted, time is indeed money. Consumers are generally willing to spend more for a service or a product if they perceive the quality to be worth the price. In this setting, customer focus equates to speed. This may explain the growing popularity of overnight delivery services such as Federal Express, Airborne Express, and Express Mail. Customers want to receive their service or product as soon as possible. "Customer satisfaction is the 'bottom line,' and since time is very important to customers, it should be [important] to us." (Tyndall, 1990:9)

Fast must be defined as it relates to the customer. Service is not fast unless the customer says it is fast.

"Terms such as lead times, on-time deliveries, cycle times, and response times represent customer service needs." (Tyndall, 1990:9) Coincidentally, base supply tracks these same four time-based indicators. Lead times are tracked as the average time for base supply to receive requisitions from sources of supply. On-time deliveries are tracked as a ratio of on-time deliveries to total deliveries. Response times are tracked in minutes by the priority of the requisition. However, both on-time delivery and response time only track the time from the base supply warehouse to the customer. The time required to receive the assets from sources of supply is not taken into consideration. Cycle time is tracked for reparable assets in the form of Repair Cycle Time.

Lead time can be equated to the logistics pipeline from various sources of supply to base supply. The logistics pipeline can be defined as: "An encompassing system through which materiel or personnel flow from sources of procurement to their point of use." (Compendium AFIT, 1981:522) A recent study showed that a reduction of one day lead time in the Air Force logistics pipeline can equate to approximately $50 million in savings (Bond and Ruth, 1989:2). On-time delivery and the percentage of on-time delivery are highly visible measures that base supply tracks daily and monthly, respectively. On-time delivery of parts to flightline repair shops is deemed critical to supporting the flying mission.

The cycle time equivalent is repair cycle time. Base supply keeps track of the turnaround time for reparable items, providing a form of measure for the maintenance organization and creating an incentive to continuously improve the time. Response time can be measured in base supply by "days to process requisitions." Including time factors in measures has strong implications for customer service and continuous improvement.

Two critical questions must be answered with regard to measurement. The first question deals with when the data will be collected, and the second question deals with when the data will be reported (Kinlaw, 1992:72). The M-32 is a report that is produced monthly and can only be produced on an as-required basis with a great amount of difficulty. "We cannot possibly commit to continuous improvement if we collect data only when we have a problem rather than collecting data as a way of doing business." (Kinlaw, 1992:16) As noted before, Juran states that measures must be taken during a process to be of use to those responsible for improving the process, and "real-time information is necessary to permit prompt detection and correction of nonconformance to goals." (Juran, 1989:156)

Cost. Like most government agencies, the base supply organization, despite its function as a retail sales store for the base, does not operate in a profit-seeking environment. However, as a result of Executive Order 12637 signed by President Ronald Reagan in 1988, which established

a government-wide program to improve the quality, timeliness, and efficiency of the federal government, techniques used in profit-seeking organizations have been advocated for use in the federal government (Harr and Godfrey, 1992:52). An immediate effect for the Air Force has been the Defense Management Review Decision (DMRD) 901, which calls for a major reduction in the Air Force inventory.

The Air Force Materiel Command (AFMC) has a dedicated "Inventory Reduction Team" whose main function is to reduce inventory throughout the Air Force. The purpose of reducing the inventory is to lower the overhead cost associated with carrying excess inventory. Management of inventory is a continuous process (Illsley, 1992).

Number of outstanding back orders is a direct reflection of customer service. Customers want the product or service they paid for immediately. The philosophy for back orders in base supply is similar to a profit seeking organization in that both set a customer service level knowing that there will be a certain number of backorders. The customer service level is a management decision taking into consideration ordering costs versus holding costs. With the implementation of DMRD 904, the initiative to allow local commanders to have more control over how their funds are spent, backorders and their associated costs will be scrutinized ever more closely.

Logistics Quality Indicators. "The biggest stumbling-blocks to quality now are the lack of clarity on what to measure, and the lack of information systems to support such measurement" (Read and Miller, 1991:36). In addition to this observation, Read and Miller found that past performance measures need to be changed in order to align them with quality objectives.

Management indicators are necessary tools in determining the success of logistics organizations. The old adage "use the proper tool for the proper job" is as appropriate here as it is elsewhere. Management indicators that are not in sync with the strategic objectives of the organization are misleading at best (Cross and Lynch, 1988-89:24). If quality improvement is a strategic goal of an organization, then management indicators should be geared toward measuring quality based on the organization's definition of quality improvement.

Quality indicators should be defined from the perspective of the customer.

> Define 'on time' in the customer's terms and customer service as the customer sees it. This applies not only to the external customers but to the customers within your company who rely on your product or service. (Trunick and Richardson, 1990:19)

Knowledge of exactly who the customer is and what the customer needs is essential in order to develop effective management indicators. "Clearly, the biggest challenge for quality managers now is to determine what truly constitutes

customer satisfaction, and to translate that into measurable terms" (Read and Miller, 1991:35).

Knowledge of the customer and their needs is not the only ingredient in meaningful management indicators. Timeliness of information is also crucial to the effectiveness of logistics measures. Indicators that show end results of processes are less effective than those that show the progress of the individual process. End-result indicators tend to hide individual problem areas. For example, the fact that one process is much worse than normal could be hidden in a report showing the average performance of many processes.

Ad hoc information can often be more important to managers than structured, scheduled reports. "Reports such as sales summaries and monthly budget summaries may not zero in on current business problems" (Schultheis and Sumner, 1992:656). These same reports can be easily manipulated to hide individual abnormalities unless the indicators are broken down to the individual processes, and reports are published as required, rather than on a scheduled basis.

Characteristics of a Good Metric

AFMC Metrics Handbook. The Air Force Materiel Command's Metrics Handbook provides eight attributes of a good metric. They are:

1) It is accepted as meaningful to the customer
2) It tells how well organizational goals and objectives are being met through processes and tasks

3) It is simple, understandable, logical and repeatable
4) It shows a trend
5) It is unambiguously defined
6) Its data is economical to collect
7) It is timely
8) It drives the "appropriate action"

(AFSC, 1991:2-1)

ACCEPTED AS MEANINGFUL TO THE CUSTOMER relates directly to customer focus in that it must be important to the customer. HOW WELL GOALS ARE BEING MET THROUGH PROCESSES emphasizes not only whether the goals are being met but how they are being met and how processes can be improved to better meet the goals. Measures should be SIMPLE so that they can be understood by everyone in the organization as well as by the customers and REPEATABLE so that processes can be tracked over time to better determine areas for improvement.

SHOWING A TREND is a simple and logical attribute that can be easily applied and is one of the primary tools of TQM and process improvement. As a matter of a fact, the Base Supply Analysis Section's primary job is to keep track of supply management indicators and inform the Chief of Supply of positive or negative trends during the monthly Chief of Supply "How Goes It." However, if supply managers are reviewing non-quality based indicators, then they are wasting their time.

UNAMBIGUOUSLY DEFINED is very similar to SIMPLE, UNDERSTANDABLE, AND LOGICAL. ECONOMICAL DATA COLLECTION implies that the data should be readily available. This research applied this concept because there were already enough processes being measured and adding any more to the

ones already in the system would be redundant and cost prohibitive. In order to improve a process, TIMELY measures must be taken so that problems can be identified as they occur and corrective action can be taken immediately. Finally, DRIVING THE APPROPRIATE ACTION should result in continuous process improvement and hopefully improve customer focus.

Weaver's Attributes for Quality Indicators. Weaver introduced six characteristics that he considered important in developing quality indicators. They are:

1) Important
2) Easily understood
3) Controlled by the function's actions
4) Evaluate change
5) Use existing data
6) Measure both efficiency and effectiveness

(Weaver, 1991:105)

Five of the six characteristics relate to the customer focus and continuous process improvement framework utilized in this research. The first characteristic, IMPORTANT, relates to customer focus in that it must be important to the customer. The second characteristic, EASILY UNDERSTOOD, is obvious but does not strongly correlate to either customer focus or continuous process improvement. It may be necessary to state it as a requirement, but due to its intuitiveness, it could be argued that it does not belong as one of the six most important characteristics for quality measurement. The third characteristic, CONTROLLED BY THE FUNCTION'S ACTIONS, relates to continuous process

improvement. If the organization does not have control over the process being measured, then continuous process improvement cannot occur. The fourth characteristic of EVALUATING CHANGE also relates to continuous process improvement. In order to continuously improve, an organization must be able to gauge progress, or in some cases, retrogression. As far as USING EXISTING DATA, this research applied this concept. This characteristic makes sense because it saves time and there are already enough processes being measured without adding more to those currently in the system.

The final characteristic of MEASURING BOTH EFFICIENCY AND EFFECTIVENESS relates to both customer focus and continuous process improvement. A brief definition of efficiency can be stated as a "relationship between inputs and outputs, or how well the organization uses its inputs to produce its outputs." (Weaver, 1991:106) The organization itself can keep track of input to output ratio to measure its efficiency. Effectiveness relates to both customer focus and continuous process improvement. It can be defined as "the extent to which an organization accomplishes its mission." (Weaver, 1991:106) The customer will decide whether the organization is effective.

Complaints About Indicators. Research by Cross and Lynch showed that managers had four major complaints about

the way their operations were being evaluated. These complaints can be summarized as follows:

1. Performance measures were not in tune with the corporate strategy and were, therefore, yielding irrelevant or misleading information and provoked behavior that undermined achievement of their strategic objectives.
2. These performance measures were distorting management's understanding of how the organization was operating.
3. Traditional performance measures did not take into consideration the requirements of internal and external customers.
4. Bottom-line measures came too late to make mid-course corrections. (Cross and Lynch, 1988-89:23-24)

The first two complaints could be alleviated by indicators that possessed the Metrics Handbook attributes of "telling how well goals are being met through processes," "unambiguously defined," and "driving the appropriate action" and Weaver's characteristics of "important" and "easily understood." An example of the first complaint in base supply is the Releveling Frequency measure. By releveling the system too frequently, stock is ordered too frequently resulting in excess stock and wasting transportation expenses. A base supply example of the second complaint would be looking at Stockage Effectiveness ratings by themselves without taking Issue Effectiveness into account. A high stockage effectiveness may give a false impression to management of how well supply is supporting the customer. A disparity between stockage and issue effectiveness can mean that base supply is stocking items that the customer does not need.

The third complaint deals mainly with the customer focus aspect of the measure. Measures that are customer focused and are "accepted as meaningful to the customer" can alleviate this complaint. By attempting to achieve an extremely high inventory accuracy, supply often inventories the same stock more than once, degrading customer support and causing excess work for the warehouse personnel. In this case, improving the inventory accuracy by even one or two percentage points may not be worth the consequences.

The final complaint, not having "timely" measures, is common in base supply. This complaint can be alleviated with indicators that "evaluate change" instead of simply reporting the after effects of change. Numerous monthly management reports, such as the M-32, are heavily relied upon by supply officers for management information. The information contained in the monthly reports often highlights problems almost a month old.

Proposed Measures

Emmelhainz provides two generic measures that can be applied in quality measurement. They are cycle time and defects per unit (Emmelhainz, 1991:35). The author strongly recommends that both measures be used concurrently. He also states that "A defect free product or service delivered in a timely manner is precisely what customers want. If your logistics organization can do these two things, the cost of doing so will also be the lowest possible." (Emmelhainz,

1991:37) Cycle time relates to time factors which will be used to evaluate customer focus and continuous process improvement. Defects per unit relates to continuous process improvement. A supply example could be the Demand Processing section being measured on the number of transactions processed versus the number of errors.

Stickler presents six measures that can be used by manufacturing companies to move toward a world class organization. They are:

1) Cycle time by product
2) Inventory turn by product
3) Set up times on equipment
4) Output/Productivity by product per person
5) Quality-rejected material
6) Suggestion for improvements by product per day per person (Stickler, 1989:40).

At first glance, the above measures appear to be applicable only to a manufacturing company. However, five of the six measures can be related to supply functions and can therefore be tracked by a base supply organization. SET UP TIMES ON EQUIPMENT is more of a maintenance function. While not a specific supply function, this measure can be used to improve the organization by applying Emmelhainz' cycle time and defects per unit which will be discussed later. CYCLE TIME BY PRODUCT is another factor that can induce continuous process improvement if applied correctly using a combination of cycle time and defects per unit. INVENTORY TURN BY PRODUCT aids in keeping track of time, a customer focus function, and also measuring improvement in terms of time.

OUTPUT/PRODUCTIVITY BY PRODUCT PER PERSON relates to tracking continuous process improvement.

If the context of the phrase QUALITY-REJECTED MATERIAL can include various types of input errors, this measure is already being applied in the base supply setting. Base supply organizations track errors such as reverse-posts, rejected keyboard inputs, and warehouse refusals. These three errors are human errors that should be tracked and can be continuously reduced through training. The sixth measure, SUGGESTION FOR IMPROVEMENTS BY PRODUCT PER DAY PER PERSON, seems out of place with the first five recommendations. In a broad sense, this indicator could mean having a strong suggestions program, but the author was not specific in describing this measure. This indicator probably has the weakest application in a service-oriented organizational setting. But, if a suggestion is for improving the supply "process," then this measure could definitely apply.

Air Force Supply Indicators

Air Force quality improvement (TQM) programs are relatively new (DOD, 1988). However, management indicators currently used by base supply managers have remained virtually unchanged for many years. The Supply Management Report (M-32) is the primary source of supply indicators used by base-level Air Force logistics officers and managers (DAF, July 1992:Ch 5, 395). The M-32 is published monthly

in a set, standard format and shows the overall monthly status of internal supply programs with little emphasis on processes. There are at least 77 indicators published monthly in the M-32, depending on the number of different types of aircraft the base supports (Hronek, March 1993).

If the M-32 is being used as supply management's primary source of information on the status of base supply, then Air Force logisticians are trying to implement quality improvement without proper quality improvement tools. These past performance measures should be realigned with the objectives of quality improvement.

Research by Greer and Moon identified six categories of supply management indicators common to Air Force supply operations:

1. Stockage Support Indicators
2. Not Mission Capable Supply (NMCS) Indicators
3. Priority Support Indicators
4. Warehouse Storage Indicators
5. Repair Cycle Indicators
6. Computer Utilization Indicators (Greer & Moon, 1981:41).

Computer Utilization Indicators are no longer relevant to base supply since base supply no longer maintains the mainframe computer.

A review of AFR 900-14, USAF Supply Effectiveness Awards and appropriate guidance letters, revealed that the following 14 indicators were being used when evaluating bases for the Daedalian and Supply Effectiveness Awards:

1. Mission Capable Rate
2. Total Not Mission Capable Supply Rate
3. Bench Stock Availability

4. Recoverable Stockage Effectiveness *
5. Consumable Stockage Effectiveness *
6. Recoverable Issue Effectiveness *
7. Consumable Issue Effectiveness *
8. Percent Repairable This Station *
9. System Support Division (SSD) Stockage Effectiveness
10. General Support Division (GSD) Stockage Effectiveness
11. SSD Issue Effectiveness
12. GSD Issue Effectiveness
13. Item Records Past Due Inventory
14. Inventory Accuracy *

Asterisks identify indicators found in the M-32.

Telephone interviews with four CONUS MAJCOM supply analysts responsible for tracking indicators from their subordinate bases revealed that the indicators in Table 1 were being used. Three of the four MAJCOMs identified the indicators they use when evaluating their subordinate supply accounts. The fourth MAJCOM, Air Force Materiel Command, is not currently reviewing indicators due to a recent major reorganization.

The indicators in Table 1 are used most frequently by four CONUS MAJCOMs to review the status of their subordinate supply accounts. Stockage Effectiveness and Bench Stock Availability are the only indicators common to three MAJCOMs.

TABLE 1

INDICATORS IDENTIFIED BY MAJCOM

INDICATOR		ACC	AETC	AMC
1. Stockage Effectiveness (overall)	*	X	X	X
2. Issue Effectiveness (o/a)	*	X	X	
3. Stockage Effectiveness (PWS)	*	X		X
4. Issue Effectiveness (PWS)	*			X
5. Bench Stock Availability		X	X	X
6. Item Records with R/O & Zero Acc				X
7. Retail Sales Issue Eff.				X
8. Receipt Not Due In Rate	*		X	X
9. Rex Code 1,3,4 Rate	*			X
10. Releveling Frequency	*		X	X
11. Follow-up Frequency	*		X	X
12. GSD Orders vs. Sales			X	
13. Serv Balance W/ No Whse Location	*		X	X
14. Warehouse Refusal Rate			X	X
15. Reverse Posts	*		X	
16. Equipment Data Bank			X	
17. Inventory Accuracy			X	

* - Indicators found in the M-32

During the process of identifying the most commonly used supply indicators, it was discovered that there was very little consensus among the sources as to which indicators were important. Only one indicator out of 28 (bench stock availability) was identified by all sources. Out of the 14 indicators identified by AFR 900-14, only two were being reviewed by at least one MAJCOM (inventory accuracy and bench stock availability). Neither inventory accuracy nor bench stock availability are indicators found in the M-32. Only nine of the 28 indicators were reviewed

by more than one MAJCOM. Overall, only ten of 28 indicators (36%) were identified by more than one source.

The research into Air Force supply management indicators revealed that out of at least 77 indicators found in the M-32, only eight indicators are used by more than half of the four CONUS MAJCOMs when reviewing the status of base supply accounts. One major command found it necessary to manually combine indicators to come up with a new metric to meet their needs (Pecoraro, 1993). Another command is using only one M-32 indicator (Page, 1993). These results imply that the current indicators may not be meeting the needs of the Air Force.

All indicators which were identified in the Supply Effectiveness Award evaluation and/or by more than one MAJCOM were retained for further research. Based upon these criteria, the original 28 indicators were narrowed to the 18 indicators in Table 2. The formulas for these indicators may be found in Appendix A.

TABLE 2

INDICATORS SELECTED FOR RESEARCH

	INDICATOR	
1.	Stockage Effectiveness (overall)	
2.	Issue Effectiveness (overall)	
3.	Stockage Effectiveness (primary weapon system)	
4.	Mission Capable Rate	
5.	Total Not Mission Capable Supply	
6.	Bench Stock Availability	
7.	Recoverable/Consumable Stockage Effectiveness	*
8.	Recoverable/Consumable Issue Effectiveness	*
9.	Receipt-Not-Due-In Rate	
10.	Releveling Frequency	
11.	Percent Repairable This Station (overall)	
12.	Follow-up Frequency	
13.	System Support Division (SSD) and General Support Division (GSD) Stockage Effectiveness	*
14.	SSD and GSD Issue Effectiveness	*
15.	Serviceable Balance With No Warehouse Location	
16.	Warehouse Refusal Rate	
17.	Item Records Past Due Inventory	
18.	Inventory Accuracy	

* - Due to the similarity of these indicators, they have been treated as the same for research purposes.

Summary

A review of pertinent publications and interviews with supply analysts at the four major CONUS MAJCOMs resulted in identification of the 18 most commonly used supply indicators (see Table 2). These indicators were identified

in the Daedalian Award evaluation and/or by more than one MAJCOM.

The relationship between the 18 indicators and the Quality-Based Metrics Framework is presented in Table 3. These ratings were given by the authors based on knowledge of the supply process, review of the formulas for the indicators, and analysis of the focus group comments. An "S" implies a strong presence, a "W" implies a weak presence, a "W-" indicates a very weak presence, and a "-" indicates no presence of the characteristic in the indicator.

The indicators support Continuous Improvement to the greatest extent. This implies that supply indicators are primarily geared toward internal measurement. The indicators strong in continuous improvement reflect effectiveness of training. Customer Focus is well supported by only five of the indicators. Two of these indicators, MICAP Rate and TNMCS are mission focused. As evident in the table, none of the indicators measure time and only one, Inventory Accuracy, strongly measures cost, even though supply organizations manage millions of dollars in assets.

The importance of Customer Focus and Continuous Process Improvement on TQM cannot be overemphasized. The need to incorporate the supporting elements of time and cost into metrics is readily apparent. Emmelhainz, Stickler, Weaver, and The Metrics Handbook all emphasize the importance of

TABLE 3

RELATIONSHIP BETWEEN ORIGINAL INDICATORS AND FRAMEWORK

INDICATOR	CF	CI	Time	Cost
Stockage Effectiveness (overall)	-	W	-	W
Issue Effectiveness (overall)	W	W	-	W
Stk Eff (primary weapon system)	S	W	-	W
Mission Capable Rate (MICAP)	S	W	-	-
Total Not Mission Capable Supply	S	S	-	-
Bench Stock Availability	S	W	-	-
Recoverable/Consumable Stk Eff	-	W-	-	W-
Recoverable/Consumable Iss Eff	W-	W-	-	W-
Receipt-Not-Due-In Rate	W-	W	-	-
Releveling Frequency	-	-	-	-
Percent Repairable This Station	W	W	-	W-
Follow-up Frequency	-	-	-	-
SSD/GSD Stockage Effectiveness	-	W-	-	W-
SSD/GSD Issue Effectiveness	W-	W-	-	W-
Serv Balance w/No Warehouse Loc	W	S	-	W
Warehouse Refusal Rate	S	S	-	W
Item Records Past Due Inventory	-	S	-	W
Inventory Accuracy	W	S	-	S

time factors and the timeliness of measures. The importance of cost factors is ever increasing due to the shrinking defense budget, the need for the DOD to operate more "business-like," and the emphasis on inventory reduction.

The Quality-Based Metrics Framework is not readily apparent in supply management indicators. The lack of appropriate measures for supply organizations hampers the effectiveness and efficiency of the entire Air Force.

Chapter 3 will present the method used to develop supply indicators based on the Quality-Based Metrics Framework. The steps taken to verify and validate the indicators will also be presented.

III. Methodology

The methodology presented in this chapter was used to answer the investigative questions posed in Chapter 1. These four questions were answered through the procedures outlined in this chapter. The first two questions were answered through a combination of literature searches and personal interviews. The second two questions were answered by presenting information to senior supply managers through a Group Support System.

Desired Characteristics

Investigative question #1:

According to the TQM philosophy, what are the appropriate characteristics which management indicators should possess in order to assess the performance of base supply?

A literature review was conducted to identify the characteristics that a indicator should possess under the TQM philosophy. This literature review covered TQM philosophies both within the federal government and the private sector. This investigation determined that the major characteristics performance indicators should possess in accordance with the TQM philosophy are 1) a customer/ mission focus and 2) an indication of how to improve the supply process.

Common Indicators

Investigative question #2:

What are the most commonly used supply management indicators?

In order to determine the most commonly used supply management indicators, an initial review of past AFIT Theses was conducted to determine indicators that were considered important. Next, a review of Air Force publications on the USAF Supply Effectiveness Awards identified indicators that are evaluated by the Air Staff when selecting the outstanding supply unit of the year. Finally, senior supply analysts at the four CONUS MAJCOMs were interviewed via telephone. Three of the four identified which indicators they used when evaluating their subordinate supply accounts. The fourth MAJCOM, Air Force Materiel Command, is not currently reviewing any indicators from subordinate supply accounts due to a recent major reorganization.

All indicators which were identified in the Supply Effectiveness Award evaluation criteria or by more than one MAJCOM were used. The list of indicators and where they were identified are listed in Table 4. The total number of indicators used in this research was 18 (see Table 5 and Appendix A).

TABLE 4

INDICATORS IDENTIFIED BY AT LEAST ONE SOURCE

INDICATOR	AFR 900-14	SOURCE ACC	AETC	AMC
Stockage Effectiveness (overall)		X	X	X
Issue Effectiveness (o/a)		X	X	
Stockage Effectiveness (primary weapon system)		X		X
Issue Effectiveness (primary weapon system)				X
Mission Capable Rate	X			
Total Not Mission Capable Supply (TNMCS) Rate	X			
Bench Stock Availability	X	X	X	X
Item Records with R/O & Zero Acc				X
Recoverable Stockage Eff.	X			
Consumable Stockage Eff.	X			
Retail Sales Issue Eff.				X
Recoverable Issue Eff.	X			
Consumable Issue Eff.	X			
Receipt Not Due In Rate			X	X
Rex Code 1,3,4 Rate				X
Releveling Frequency			X	X
% Repairable This Station	X			
Follow-up Frequency			X	X
System Support Division (SSD) Stockage Effectiveness	X			
SSD Issue Effectiveness	X			
General Support Division (GSD) Stockage Effectiveness	X			
GSD Issue Effectiveness	X			
GSD Orders vs. Sales			X	
Serviceable Balance With No Warehouse Location			X	X
Warehouse Refusal Rate			X	X
Item Records Past Due Inventory	X			
Reverse Posts			X	
Equipment Data Bank			X	
Inventory Accuracy	X		X	

TABLE 5

INDICATORS PRESENTED TO FOCUS GROUP

	INDICATOR	
1.	Stockage Effectiveness (overall)	
2.	Issue Effectiveness (overall)	
3.	Stockage Effectiveness (primary weapon system)	
4.	Mission Capable Rate	
5.	Total Not Mission Capable Supply	
6.	Bench Stock Availability	
7.	Recoverable/Consumable Stockage Effectiveness	*
8.	Recoverable/Consumable Issue Effectiveness	*
9.	Receipt-Not-Due-In Rate	
10.	Releveling Frequency	
11.	Percent Repairable This Station (overall)	
12.	Follow-up Frequency	
13.	System/General Support Division (SSD and GSD) Stockage Effectiveness	*
14.	System/General Support Division (SSD and GSD) Issue Effectiveness	*
15.	Serviceable Balance With No Warehouse Location	
16.	Warehouse Refusal Rate	
17.	Item Records Past Due Inventory	
18.	Inventory Accuracy	

* - Due to the similarity of these indicators, they have been treated as the same for the purpose of this research.

Indicator Usefulness

Investigative question #3:

In terms of TQM, how useful are these indicators to base supply officers?

A focus group is defined as a panel of respondents led by a moderator. The moderator uses principles of group dynamics to focus or guide the group in an exchange of ideas, feelings, and experiences on a clearly understood

topic (Emory and Cooper, 1991:147). A focus group was used to evaluate the usefulness of these indicators, in terms of TQM, to supply managers using a modified Nominal Group Technique. The focus group was decided upon because a great deal of research has shown that decisions made by five or more participants are superior to individual decision making (Gibson and others, 1991:585; Meister, 1985:318; Hare, 1982:329).

Nominal Group Technique. The technique used in this portion of the research is a modified Nominal Group Technique (NGT) method of effecting group decision-making. NGT is defined as a "Technique that promotes creativity by bringing people together in a very structured meeting that allows little verbal communication. Group decision is the mathematically pooled outcome of individual votes" (Gibson and others, 1991:589). A NGT process consists of four steps:

1. Silent judgments by individuals in the presence of the group.
2. Presentation to the group of all individual judgments without discussion.
3. Group discussion of each judgment for clarification and evaluation.
4. Individual reconsideration of judgments and mathematic combination. (Meister, 1985:319)

This research modifies the NGT as follows:

1. Anonymous open discussion by all participants via the GSS network.

2. Open verbal group discussion of alternatives.

3. Individual consideration and judgment of all alternatives with previous comments available for review.

4. Mathematic combination of judgments.

These modifications were necessary to more effectively present information and gather data using the GSS network (Wolfe, 1993).

Group Support System. A Group Support System (GSS) was used to facilitate the modified NGT process. A GSS is different from a Group Decision Support System (GDSS) in that the GDSS is usually an on-line system that is linked with large data bases so that a group of individuals have access to the same data. Group Support Systems are:

> ...computer-based systems that provide a variety of tools to facilitate the meeting process. In part these systems are electronic implementations of older methods - e.g. Delphi and NGT - that have been used to improve the quality of meetings over the last 30 years.
> (Armstrong Laboratory)

The GSS used in this research is located in the Armstrong Laboratory, Area B, Wright-Patterson AFB, OH. The Logistics Research Division of the Armstrong Laboratory performs research on technology for improving performance with integrated systems. This GSS is part of another on-going research project on the potential of Group Support Systems (Armstrong Laboratory). The software used in this research is GroupSystems V by Ventana Corporation (copyright

1990-1992, Ventana Corporation, copyright 1988-1989 MIS Department, University of Arizona).

Focus Group Selection.

Population of Interest. The population of interest for the members of the focus group is the 955 United States Air Force commissioned officers currently serving in all 64XX Air Force Specialty Codes (AFSCs)(Egge, 1992).

Sample. There were 11 volunteers for the focus group. The actual focus group consisted of five members, due to scheduling constraints. Research has shown that this number is appropriate when using the Nominal Group Technique (Gibson and others, 1991:589; Hare, 1982:142; Hare, 1976:231; Jewell and Reitz, 1981:86). A judgment sampling technique was used to select officers from the population of interest. The criteria for inclusion in the focus group included:

- members must have at least ten years of Air Force supply experience.
- members must hold the rank of Captain, Major, Lieutenant Colonel, or Colonel.
- members must be familiar with the M-32 Supply Management Report.
- members must have prior TQM training.
- members must voluntarily participate.

Indicator Evaluation. A focus group was used to evaluate the indicators identified in the second

investigative question (Table 5) through the modified NGT. The focus group met at the GSS room in the Armstrong Laboratory where they were given an initial briefing on the GSS by the laboratory staff. Periodic breaks were taken to help prevent fatigue and eye strain.

Dry Run. After the initial briefing, the research team explained to the members of the focus group the purpose of the research and the procedures to be followed while using the modified NGT. At this time, three supply indicators that were not among any of the 18 identified in Table 5 were used to familiarize the focus group members on the computer system and the NGT. The following procedures were used to conduct the dry run and the actual evaluation.

Actual Evaluation. Once the dry run was completed, the actual indicators under study were presented to the group for evaluation using the Topic Commenter software option (see Appendix A).

First, all the supply indicators were displayed on each individual screen. Each of the 18 indicators was displayed on its own commenter card. There were 19 cards displayed. The first 18 contained the indicators from Table 5 and the last card was left for generic comments.

The researchers then asked the group to make comments about the first five indicators (only) in relation to the following two questions: "How well does this indicator reflect customer/mission support?" and "How well does this indicator lead you to continually improve the process?" The

comments were limited to the first five indicators so that no one would get too far ahead of the group.

Without verbal discussion, each individual then typed comments about the indicator in relation to two questions asked by the researchers. The GSS recorded and collated the comments and displayed them on an overhead viewing screen anonymously, as they were entered. Once all participants commented and electronically replied to the comments on each indicator, the research team led the group in a structured discussion on each comment so that the comment could be clarified, if necessary, and examined by the entire group.

At this point, a break was taken. After the break, the above process was repeated for the next group of five indicators. This continued until all indicators were covered.

After all of the indicators had been covered, each participant was asked to make any comments relating to supply management indicators, how to improve them, and possible alternative indicators on the last commenter card. These comments were used to help modify indicators in order to answer the fourth investigative question.

After all indicators were commented upon and discussed, participants rated each indicator on how well it reflected the level of customer support and how well it would lead them to continually improve the supply process. The ratings were on a scale of 1 to 10, with 1 meaning little or no indication of the level of customer support/continuous

improvement and 10 being an extremely high indication of the level of customer support/continuous improvement. The 1 to 10 scale was used as that is the only rating scale supported by the software.

The software allowed participants to abstain from voting on any indicator. To ensure more accurate data collection, participants were allowed to abstain from voting on any indicator with which they were unfamiliar.

After the data collection process was complete, the mean, standard deviation, and median of the ratings on each indicator was computed for each criterion (customer/mission focus and process improvement). These numbers, along with the individual participant ratings, were listed in the order in which they were presented (see Figure 2 and Appendix C). Finally, all indicators were rank ordered by the median rating for each criterion and by the sum of the two criteria ratings. The mean and standard deviation were used to break any ties (see Appendix C).

The median was decided upon rather than the mean because the median is less sensitive than the mean in small measurements and is a better measure of central tendency in this situation (McClave and Benson, 1991:89).

The above information on each indicator was analyzed for possible modification and improvement of the indicators in accordance with the fourth investigative question.

1. STOCKAGE EFFECTIVENESS - (OVERALL)

* Criteria *	Participant Ratings 1	2	3	4	5	6	7	8	9	10	N	n	MN	SD	MD
Customer/ Mission Focus	-	-	-	-	2	-	2	1	-	-	5	5	6.4	1.3	7.0
Continuous Process Improvement	1	1	-	-	-	1	2	-	-	-	5	5	4.6	2.8	6.0

2. ISSUE EFFECTIVENESS - (OVERALL)

* Criteria *	Participant Ratings 1	2	3	4	5	6	7	8	9	10	N	n	MN	SD	MD
Customer/ Mission Focus	-	-	-	-	1	1	1	-	2	-	5	5	7.2	1.7	7.0
Continuous Process Improvement	-	1	1	-	1	-	1	-	1	-	5	5	5.2	2.9	5.0

Figure 2. Partial List of Indicator Ratings

Modifying Indicators

Investigative question #4:

Can these supply indicators be modified so that they are more in-line with the TQM philosophy?

The researchers attempted to modify all indicators to bring them more in line with the TQM philosophy. Any indicator with median ratings of eight or greater on each criteria is strong in both customer focus and process improvement. These indicators were considered appropriate indicators to use according to the TQM philosophy and were retained along with their modified versions, if they were modified.

The process of modifying the indicators consisted of:

1. Identifying the source data from which the indicators are derived.

2. Applying content analysis to analyze the inputs from the focus group.

3. Analyzing the source data and focus group inputs to see whether it was feasible to modify the current indicators.

The indicator sources were found in investigative question #2. This was primarily the M-32 report. Those indicators not found in the M-32 report were identified by the researchers through AFM 67-1 and interviews with supply analysts.

Focus group comments were examined using content analysis. The researchers separately analyzed each comment made by the group and rated the comment as positive, negative, or neutral as the comment related to the aspects of customer focus or process improvement. The following formula was used to rate the intercoder reliability (IR) of the researchers:

$$IR = \frac{Number\ of\ Agreements}{Total\ Number\ of\ Comments}$$

(Miles and Huberman, 1984:63)

After the intercoder reliability was calculated, the researchers discussed the comments and reevaluated their ratings. The intercoder reliability was recalculated as recommended by the text, and the reliability was found to be extremely high.

In order to modify the indicators, the focus group comments, the characteristics identified in the first investigative question, and Juran's quality formula were

applied wherever possible. Juran's quality formula is as follows:

$$QUALITY = \frac{Frequency\ of\ Deficiencies}{Opportunities\ for\ Deficiencies}$$

(Juran, 1989:200).

The above formula is simply applying ratios to measures in order to establish a baseline for continuous process improvement. An example of a supply application of this formula is the Receipt-Not-Due-In Rate. The numerator would be "number of receipts without a corresponding due-in," while the denominator would be "total number of receipts." By using only the number of receipts-not-due-in without considering the opportunities for deficiencies, there is no baseline for trend analysis or comparison between organizations.

As a result of the above process, three indicators were not modified, eight were modified versions of original indicators, two were current supply indicators that were not any of the original indicators, and five were new indicators developed by the researchers.

Quality Improvement. In order to determine whether the revised indicators were an improvement over the original indicators, a second focus group meeting was conducted. This focus group consisted of the same sample as the first focus group in order to reduce potential difference bias.

Indicator Evaluation. The focus group was used to evaluate the indicators modified by the research team. The focus group used the GSS at Armstrong Laboratory to evaluate the revised indicators. The individuals were allowed to evaluate the indicators at different times. The same questions were posed and members used the same scale to rate the revised indicators.

The ratings of both focus group meetings were compared to determine if the revised indicators more fully met the requirements for useful indicators in terms of TQM.

This was accomplished by conducting a one-tailed t-test to determine if the revised indicators were significantly better than the original indicators. The average median rating of the indicators from the first focus group meeting was compared with the average median rating of the revised indicators from the second focus group meeting. An alpha (α) of .05 was used.

The Test of Hypothesis was conducted as follows:

H_o: No difference between the average medians of the two focus group meetings.

H_a: The average median of the second focus group meeting is greater than that from the first.

$$\textit{Test Statistic: } t = \frac{(\mu_2 - \mu_1)}{(\frac{S}{\sqrt{n}})}$$

$$\textit{Reject region: } t > t_\alpha, \textit{ where } t_\alpha \textit{ has } n - 1 \textit{ df.}$$

Where μ_1 is the average median score of the indicators from the first focus group meeting and μ_2 is the average median score from the second focus group meeting. The results of this test verified whether or not the revised indicators were an improvement over the original indicators in terms of TQM.

Using statistical and content analysis, a final group of indicators was produced. This group of indicators underwent a double screening process by experienced supply officers and should be useful metrics. In addition, these metrics were evaluated by a larger sample of field grade supply officers throughout the Air Force to validate these findings.

Validation. In order to determine the validity of these indicators throughout the Air Force, questionnaires were sent to all field grade supply officers at the CONUS MAJCOMs, the Air Force Logistics Management Agency, and the Standard Service Center. All officers met the same criteria as those in the focus group. These questionnaires contained the final 18 metrics as determined by the researchers through the two focus group meetings (see Appendix G).

The officers rated each indicator on a scale of 1 to 10 on the same two criteria as the focus group. The ratings from the questionnaires were compared to determine if the results from the focus group were consistent across the Air Force.

Due to different sample sizes, the researchers used non-parametric statistics to compare the results of the survey ratings with the focus group results. The indicators were ranked from highest to lowest median with ties being broken in favor of the highest mean and if necessary, lowest standard deviation.

The Wilcoxon Rank Sum Test was used to determine which group of officers rated the indicators higher. Focus group ratings equal or lower than the ratings from the questionnaires sent to the sample of supply officers throughout the Air Force implies potential Air Force-wide application.

The Test of Hypothesis:

H_o: The probability distributions corresponding to the focus group and the sample are identical.

H_a: The probability distribution corresponding to the sample lies to the right or left of the probability distribution of the focus group.

Test Statistic: The rank sum T, associated with the sample.

Reject Region: Reject if $T \leq T_L$ or $T \geq T_U$ for $\alpha = .025$

Spearman's Rank Correlation Coefficient was applied to determine if the focus group and the sample rated the indicators in a similar order.

The Test of Hypothesis:

H_o: There is no population correlation between ranks.

H_a: There is a population correlation between ranks.

$$\textit{Test Statistic: } r_s = 1 - \frac{6\Sigma d_i^2}{n(n^2 - 1)}$$

$$\textit{Reject Region: } r_s < -r_{s,\frac{\alpha}{2}} \textit{ or } r_s > r_{s,\frac{\alpha}{2}}$$

Summary

This chapter outlined the methodology to be used in order to answer the investigative questions posed in chapter one. Specifically, the desired characteristics for management indicators were found through an in-depth literature review. A determination of commonly used supply management indicators was found through a literature review and telephone interviews with MAJCOM supply analysts. A determination of the usefulness of current indicators in terms of TQM was made by applying a modified Nominal Group Technique using a GSS. A modification of indicators was made by analyzing the focus group comments through content analysis and applying those comments and the desired characteristics to the original indicators. The revised indicators were then compared to the original indicators using the GSS. Finally, the results were validated Air Force-wide through questionnaires to the major commands.

The next chapter will analyze the results of this research.

IV. Findings and Analysis

Overview

The purpose of this research is to determine which management indicators should be used in order to provide supply managers with quality measurement tools. This chapter focuses on the findings and analysis of the research used to answer the third and fourth investigative questions:

- In terms of TQM, how useful are these indicators to base supply officers?
- Can these supply indicators be modified so that they are more in-line with the TQM philosophy?

In order to answer the third investigative question, the 18 indicators selected for research were presented to a focus group of highly experienced supply officers (see Table 2). The group rated the indicators and commented on their usefulness in terms of customer focus and continuous process improvement.

Content analysis was used to analyze the comments and suggestions made by the focus group. This content analysis consisted of the authors separately rating each comment as having a positive, negative, or neutral referential theme. Intercoder reliability was then calculated at 67.0 percent. The authors then discussed each comment and repeated the rating process. The final intercoder reliability was 89.4 percent. The general theme of the comments was matched against the overall ratings for each indicator in order to validate the ratings. No blatant inconsistencies were

found. This analysis, combined with the framework from the first question, was used to modify the 18 indicators per the fourth investigative question.

The revised indicators were presented to the same focus group for comments and ratings. The results of the two meetings were compared using a t-test to verify whether the revised indicators were significantly better than the original 18.

A final validation of the research was performed by sending questionnaires to all field grade supply officers at the CONUS MAJCOMs, the Air Force Logistics Management Agency, and the Standard Service Center. These officers rated the final indicators and the ratings were compared throughout the Air Force.

Usefulness of Current Indicators

A focus group, consisting of five senior supply officers, evaluated the indicators found in investigative question #2. These officers had an average of 18.4 years of supply experience (low 14, high 24), and all but one had been a Chief of Supply (COS) at least once. Three had been COS twice.

Analysis of Comments. Based on the results from investigative question #1, the focus group was asked to comment and rate the original 18 indicators in terms of how well each indicator led to continuous process improvement

and how well they indicate the level of customer support. The original comments and ratings are in Appendices B and C. (See Table 6 for the sum median and mean ratings.)

TABLE 6

SUM MEDIAN AND MEAN OF ORIGINAL INDICATORS
(CUSTOMER FOCUS + CONTINUOUS PROCESS IMPROVEMENT)

INDICATOR	MEDIAN	MEAN
Warehouse Refusal Rate	17.0	16.4
Total Not Mission Capable Supply (TNMCS)	16.0	16.0
Bench Stock Availability	15.0	14.0
Inventory Accuracy	15.0	12.8
Stockage Effectiveness (Primary Weapon System)	14.0	14.6
Stockage Effectiveness (overall)	13.0	11.0
Mission Capable Rate (MICAP)	12.0	13.0
Issue Effectiveness (overall)	12.0	12.4
Serviceable Balance w/No Whse Loc	11.0	9.4
Item Records Past Due Inventory	10.0	9.6
Percent Repairable This Station	10.0	9.2
Receipt-Not-Due-In Rate	8.0	9.0
Recoverable (Consumable) Stk Eff	7.0	7.8
Recoverable (Consumable) Iss Eff	6.0	7.6
System Support Division/General Support Division (SSD/GSD) Stk Eff	6.0	7.0
System Support Division/General Support Division (SSD/GSD) Iss Eff	5.0	6.8
Releveling Frequency	4.0	5.8
Follow-Up Frequency	4.0	4.4

Many comments revealed how these indicators are not customer focused. Comments related to the four Stockage Effectiveness indicators (Overall, Primary Weapon System, Recoverable/Consumable, and SSD/GSD) implied that these indicators are not customer oriented because these measures exclude items that are not stocked but are still needed by customers. Many of the other indicators were viewed as low-level, internal measures of very little importance to the customers. These indicators were measures of how often supply personnel were accomplishing routine tasks and measures of supplier support, limited by imposed fiscal constraints. This type of indicator included Follow-Up Frequency, Releveling Frequency, SSD/GSD indicators, and Repairable/Consumable indicators.

Some indicators were viewed as being more customer focused. Issue Effectiveness indicators can show how well supply anticipates customer requirements because they include items that are not stocked in their calculation. Customers do not care whether or not supply is authorized to stock an item. Bench Stock Availability and Warehouse Refusal Rate both were commented upon as high in customer focus. They are both direct measures of how well supply supports the customer. MICAP and TNMCS rates are measures that show how well supply supports the mission and, therefore, received many positive comments.

Comments revealed that many of the indicators do not lead to continuous process improvement. The four Stockage

Effectiveness indicators are primarily controlled by fiscal constraints and depot support. The current formulas leave room for potential manipulation by supply to artificially inflate these indicators. Neither Releveling Frequency nor Follow-Up Frequency leads to continuous process improvement because they both deal with frequency of accomplishing rather routine tasks. Furthermore, if releveling and follow-up are done too often by overriding the computer programs, overstocking of unneeded items and inefficient use of funds can occur.

A number of indicators were viewed as supporting continuous process improvement. Receipt-Not-Due-In Rate, Warehouse Refusal Rate, and Inventory Accuracy all drive continuous process improvement, as they are good indicators of possible larger problems. This will lead supply managers to conduct additional research to find the underlying cause of the problem. Item Records Past Due Inventory, Serviceable Balance With No Warehouse Location, and Percent Repairable This Station may all drive continuous improvement at a lower, internal level. Although MICAP and TNMCS rates do not directly show areas for continuous improvement, they can lead to teamwork between supply and maintenance personnel, and they inherently motivate supply personnel to continuously improve.

Ratings. Nine of the eighteen indicators had a sum median and sum mean of 10 or less out of a possible 20.

Only two of the eighteen indicators, TNMCS and Warehouse Refusal Rate, were rated as higher than 15 in both sum median and mean. All of the five focus group members rated each of the eighteen indicators on the two criteria of customer focus and continuous process improvement. This gave a total of 180 individual ratings (5 individuals x 18 indicators x 2 criteria). There were a total of nineteen individual ratings of 9 or 10 (10.57 percent) versus forty-one ratings of 1 or 2 (22.78 percent)(see Appendix C).

Half of the indicators received very low scores overall, only two of the indicators received very high scores overall, and there were twice as many individual ratings of 1 or 2 versus 9 or 10. This implies that the currently used supply management indicators are very weak in terms of customer focus and continuous process improvement.

Additional Findings. There was general consensus among the focus group that there is a need for measures comparable between different types of bases, different commands, and different fleets. Additionally, some measures are very useful at higher organizational levels, but not very useful at lower levels. This finding is consistent with management philosophies wherein strategic goals and outlooks are more broad in focus than tactical and organizational goals, which are progressively narrower in focus. MICAP and TNMCS rates are examples of this finding. They both give commanders vital information on weapon system status but neither tell a

supply clerk how to improve the supply process or how well the clerk is directly supporting the customer.

Modification of Current Indicators

The above comments were used in conjunction with the findings in the literature research to modify, and in some cases, develop new indicators. Some indicators were given a new name. These new indicators are designed to be metrics, or meaningful indicators.

Some questions which arose during research that were considered when developing the new indicators were:

1. Does supply have control over the outcomes?
2. Can the metric be used to compare one supply organization to another?
3. Can time and cost factors be incorporated?
4. Can the metric induce continuous process improvement and show the level of customer/mission support?

As noted in the literature review, indicators should be controlled by the function's actions. Without supply having control over the outcome of the indicators, continuous process improvement cannot occur. Developing metrics to compare supply organizations gives a baseline for comparison and a starting point for continuous process improvement. As recommended by Juran's quality formula, all the new metrics are in terms of ratios or averages. The Daedalian Award can use these metrics as its criteria. As supporting elements of customer focus and continuous process improvement, time and cost factors were applied wherever possible.

Analysis of Comments. A summary of comments for improving each indicator is presented in Table 7 (all original comments are presented in Appendix B).

TABLE 7

COMMENTS FOR IMPROVING INDICATORS

1. Stockage Effectiveness (overall):
   - need to look at stockage effectiveness by weapon system, not overall.
   - when more than one weapon system exists, it can create conflicting priorities.

2. Issue Effectiveness (overall):
   - Should be measured as weapon system dependent.
   - Potential good internal measure.
   - Hope the customer asks for the right thing.

3. Bench Stock Availability:
   - measure by organization.
   - survey bench stock customers for satisfaction.

4. Stockage Effectiveness (primary weapon system):
   - same as Stockage Effectiveness (overall)

5. Mission Capable Rate:
   - can be broken down further to measure true supply support.

6. Total Not Mission Capable Supply:
   - break it down further to get a clearer picture of supply.

7. Recoverable/Consumable Stockage Effectiveness:
   - too detailed to be useful.
   - maybe taking the stockage effectiveness down to a level that is so narrow it carries little weight.

8. Recoverable/Consumable Issue Effectiveness:
   - similar comments as #7 above.

9. Receipt-Not-Due-In Rate:
   - use as a ratio of total receipts.
   - useful as a rate tracked over time.

10. Percent Repairable This Station (overall):
    - An indicator that has seen its day with the introduction of 2-level maintenance.
    - Under 2-level maintenance, this is becoming meaningless.

11. Inventory Accuracy (completed plus special):
    - Great indicator (metric), keep as is.

12. Releveling Frequency:
    - This is a matter of policy.

13. Follow-Up Frequency:
    - Similar comments as #12, above.

14. Serviceable Balance With No Warehouse Location:
    - Excellent lower level metric for internal control.
    - An important lower-tier metric supporting inventory accuracy.

15. Item Records Past Due Inventory:
    - Could affect the customer, but usually doesn't. I/Rs frozen for inventory more likely to affect customer.

16. System/General Support Division Stockage Effectiveness:
    - Similar comments to #7, above.

17. System/General Support Division Stockage Effectiveness:
    - Similar comments to #8, above.

18. Warehouse Refusal Rate:
    - Keep as is.
    - Very important leading metric of inventory accuracy.

19. General Comments:
    - I believe Reverse Post rates are one of the most important indicators available to the COS.
    - Reverse Post rates are super important!
    - Let's add Reverse Post rates.
    - Suggest Reverse Post rates be included as an internal supply metric.

Tables 8 through 10 present the metrics that were developed by the researchers. The rationale for the actions taken on the indicators is discussed following each table. The revised indicators are presented in the text and the formulas for these metrics are listed in Appendix D.

Unchanged Indicators. The highly rated indicators in Table 8 were kept in their original forms.

TABLE 8

UNCHANGED INDICATORS

1. Total Not Mission Capable Supply Rate
2. Inventory Accuracy (completed plus special)
3. Warehouse Refusal Rate

Total Not Mission Capable Supply was one of the highest rated indicators. Further breakdown of this indicator was accomplished with the Mission Capable Rate, below. This indicator was kept as is: **TOTAL NOT MISSION CAPABLE SUPPLY**.

The ratings for Inventory Accuracy were relatively high and the comments were extremely positive. In addition, analysis of the formula did not indicate any areas for improvement. This indicator was kept as is: **INVENTORY ACCURACY (COMPLETED PLUS SPECIAL)**.

Warehouse Refusal Rate received the highest overall ratings. All of the comments from the focus group were very positive. The following comment was typical of the response from the focus group.

> "Very important leading metric of inventory accuracy. Can, if managed with integrity, approach zero over time. In the vein of continuous improvement, when the numbers get low, they can usually be explained individually." (Appendix B)

In addition, there were no areas for improvement of the formula. This indicator was kept as is: **WAREHOUSE REFUSAL RATE**.

The three unchanged indicators, besides being strong in both customer focus and continuous process improvement, are very useful in that they translate well between the various organizational levels. All three indicators can be used in various forms at all levels from the individual and section level to the Headquarters and MAJCOM level. An example would be the Warehouse Refusal Rate. Specific warehouse refusals could be used by section supervisors to identify training requirements for individuals. The total number of refusals could be used by mid-level managers to identify training effectiveness and reveal problem areas. The MAJCOMs can use Warehouse Refusal Rate in a ratio form to compare bases within their command.

Modified Indicators. The indicators presented in Table 9 were developed by modifying some of the original indicators.

TABLE 9

MODIFIED INDICATORS

1. Stockage Effectiveness by Weapon System
2. Issue Effectiveness by Weapon System
3. Bench Stock Availability by Organization
4. Not Mission Capable Supply Rate
5. Receipt-Not-Due-In Rate
6. Percent Repairable This Station (Three-level Maintenance)
7. Serviceable Balance With No Warehouse Location

Research showed that base supply officers have very little control over Stockage Effectiveness. Overall Stockage Effectiveness is primarily driven by funding. However, the focus group's ratings and comments indicated that this measure may still be important. Tradeoffs can be made between weapon systems. Base supply officers do have some control over this tradeoff, such as stocking at a higher level for more important customers and missions. Based on the analysis, the researchers concluded that **STOCKAGE EFFECTIVENESS BY WEAPON SYSTEM** would be a better measure.

Because Issue Effectiveness shows how well demands are anticipated, it is potentially a very good measure. Monitoring by weapon system allows the supply officer to place more emphasis on the most important customers. This measure was modified to track **ISSUE EFFECTIVENESS BY WEAPON SYSTEM**.

The comments indicated Bench Stock Availability would be better if measured by organization, as some organizations are more important customers. Therefore, Bench Stock Availability was modified to be **BENCH STOCK AVAILABILITY BY ORGANIZATION**.

MICAP rates are comprised of three factors. These factors are aircraft or weapon systems not-mission capable because of maintenance, supply, or both. Because total not-mission capable supply rates include only the supply and both factors, these researchers eliminated the "both,"

leaving **NOT MISSION CAPABLE SUPPLY**, which replaced the original MICAP rate.

Based on the comments, Receipt-Not-Due-In was slightly modified to incorporate Juran's quality ratio. As mentioned in Chapter 3, Juran's quality ratio is simply applying ratios to measurements in order to establish a baseline for continuous process improvement. In this case the frequency of deficiencies equates to number of receipts with no corresponding due-in and the opportunities for deficiencies is the total number of receipts. The new indicator is still referred to as **RECEIPT-NOT-DUE-IN RATE**.

Based on the comments, it appeared that Percent Repairable This Station had lost its value. However, Col Morris, HQ AFMC/ALG stated: "Two-level [maintenance] only applies to avionics and engines at this point, and not all of those. There will still be a lot of three-level maintenance at base level for several years." A slight modification was made to the indicator resulting in **PERCENT REPAIRABLE THIS STATION (3-LEVEL MAINTENANCE ONLY)**.

The comments for Serviceable Balance With No Warehouse Location indicate that it is an excellent operational level measure, despite the mediocre ratings. In an attempt to make this a higher-level indicator, cost factors were added. The interim measure included dollar values in place of "numbers of item records," and was presented as **SERVICEABLE BALANCE WITH NO WAREHOUSE LOCATION**.

New Indicators. The new metrics listed in Table 10 were developed or introduced into the research. Reverse Post Rate and Supply Cannibalization Rate are indicators that are currently used in varying forms but did not meet the criteria for the most commonly used supply indicators.

TABLE 10
NEW INDICATORS

1. Inventory Effectiveness Ratio (overall)
2. Not Stocked Backorder Ratio
3. Bench Stock MICAP Rate
4. Item Records Frozen For Inventory Rate
5. Time to Clear Frozen Item Records
6. Reverse Post Rate*
7. Unreported Excess Inventory Ratio
8. Supply Cann Rate*

* = denotes currently used indicators introduced to the research.

In addition to original modification made to Stockage Effectiveness (overall), cost factors in terms of on-hand inventory versus authorized inventory were incorporated to develop **INVENTORY EFFECTIVENESS RATIO (OVERALL)**. This indicator is calculated by multiplying stockage effectiveness by the percentage of authorized inventory actually on-hand. An organization with a high stockage effectiveness rate and 200 percent of authorized inventory would have a worse Inventory Effectiveness Ratio than another organization with a slightly lower stockage effectiveness but only 100 percent of authorized inventory.

Using this indicator would continuously drive inventory reduction and provide a basis for a fair comparison.

Based on comments by the focus group which emphasized the fact that customers don't care whether the item is authorized to be stocked, a new measure - **NOT STOCKED BACKORDER RATIO** was extracted from the issue effectiveness indicators. This indicator has the potential to lead supply managers to be proactive in forecasting customer demands.

Bench stock assets are typically not critical assets. However, lack of bench stock assets can cause aircraft groundings. From these comments, researchers formulated the **BENCH STOCK MICAP RATE**. This indicator is the ratio of MICAP hours due to a bench stocked item divided by the total number of MICAP hours. Although this rate will typically be zero, a bench stocked item causing a MICAP is a very strong indication of problems in the supply system or miscommunication between supply and its customers.

Inventorying in base supply is an on-going process. However, non-routine inventory can give indications of problem areas. Time factors which relate to customer support are always important to customers and were incorporated in this indicator. Based on comments and analysis, two indicators were derived from Item Records Past Due Inventory: **ITEM RECORDS FROZEN FOR INVENTORY RATE** (Number of Item Records Frozen for Non-routine Inventory divided by Total Item Records) and **TIME TO CLEAR FROZEN ITEM RECORDS** (Average Time to Clear Non-routine Frozen Item

Records). The first indicator was developed using Juran's quality ratio and the second indicator was developed by using a simple average for the baseline.

Whenever a major input error is made to the SBSS, another transaction (a reverse post) must be created to remove the error from the system. Although Reverse Post Rate was not one of the most commonly used indicators, it is currently being tracked by Air Education and Training Command. As indicated in the general comments, reverse posts are a direct measure of the efficiency of the supply operation. They can indicate training deficiencies, system anomalies, and other problems. This measure translates well between the various levels of management. This indicator can be used by upper level management as an indicator of the quality of training, while lower level management can use Reverse Post Rates to determine specific areas in need of training. For these reasons, **REVERSE POST RATE** was added to the research.

Based on a literature review which indicated that cost factors are heavily emphasized in the private sector, the researchers developed an indicator which possesses this factor. Inventory was used as the cost factor for **UNREPORTED EXCESS INVENTORY RATIO**. This indicator is calculated by dividing the total dollar value of excess materiel by the total dollar value of the inventory.

The sponsor of this research requested that cannibalization rates be incorporated as potential metrics

to be reviewed by supply officers. Cannibalization results from the customer being unable to wait for an asset from supply. For example, a part is unavailable from base supply and an aircraft needs that part to fly. Maintenance may pull that part from another aircraft and put it on the broken aircraft. Cannibalization always results in extra manhours and sometimes results in extraordinary cost outlays in the form of damaged aircraft parts.

Researchers queried several aircraft maintenance officers and concluded that there was no set formula for deriving cannibalization rates. Therefore, researchers developed a measure that only includes cannibalization actions attributable to supply functions. This indicator is **SUPPLY CANN RATE**.

Deleted Indicators. Table 11 lists original indicators that were deleted from the research. The rationale for deletion is presented in the text following the table.

Due to the negative comments, low ratings, and the fact that Stockage Effectiveness and the Issue Effectiveness rates were already modified, Recoverable/Consumable and SSD/GSD Stockage and Issue Effectiveness rates were deleted.

TABLE 11

DELETED INDICATORS

1. Recoverable/Consumable Stockage Effectiveness
2. Recoverable/Consumable Issue Effectiveness
3. SSD/GSD Stockage Effectiveness
4. SSD/GSD Issue Effectiveness
5. Releveling Frequency
6. Follow-up Frequency

Recoverable/Consumable rates break down stockage and issue effectiveness by type of assets. Both type of assets are used by most supply customers. Breaking down stockage and issue effectiveness into these two categories does not benefit the customers nor help supply managers improve customer support.

System Support Division and General Support Division identify sources of funding for assets. Base supply has little or no control over established funding levels and, again, this information does not benefit the customers nor help supply managers improve customer support.

The Releveling Frequency and Follow-Up Frequency are not controlled by base supply and are automatically accomplished by the SBSS. Improved computer technology has made these two measures virtually obsolete. Because base managers have no control over these indicators and the ratings were extremely low, these indicators were deleted.

The above procedure resulted in a list of 18 indicators to be validated by a second focus group meeting. These indicators are listed in Tables 8 through 10 and Appendix D.

Indicator Verification. The 18 revised indicators were presented to the same group of supply officers in a second focus group meeting. The officers gave comments and rated the revised indicators, using similar procedures as before. No verbal discussion was necessary, as the officers were already familiar with the indicators and most indicators were modified based upon their comments. Comments and ratings from the second focus group meeting are listed in Appendices E and F. The ratings are summarized in Table 12.

Overall, the revised indicators were rated higher than the original indicators. While ten of the original indicators had combined median scores of less than 11, only three revised indicators scored that low. Eight of the revised indicators had median scores of greater than 15, while only three of the original indicators scored as well.

The indicator "Serviceable Balance with No Warehouse Location" was modified to incorporate the dollar value of inventory in place of the total number of line items. This modification proved to be fruitless because, as pointed out by the focus group, one high dollar value item or many low dollar value items may dramatically skew this indicator. Upon analysis of the comments from both focus group meetings, researchers decided to retain this indicator in its original form.

TABLE 12

RATINGS OF REVISED INDICATORS

Median	Mean	INDICATOR
18	17.2	*BENCH STOCK-MICAP RATE
18	16.6	BENCH STOCK AVAILABILITY (BY ORGANIZATION)
16	15.8	*TIME TO CLEAR FROZEN ITEM RECORDS
16	15.2	SUPPLY CANN RATE (BY WEAPON SYSTEM)
15	14.4	STOCKAGE EFFECTIVENESS (EACH WEAPON SYSTEM)
15	14.0	ISSUE EFFECTIVENESS - (EACH WEAPON SYSTEM)
15	13.8	NOT MISSION CAPABLE SUPPLY RATE
15	13.6	WAREHOUSE REFUSAL RATE
14	14.4	*ITEM RECORDS FROZEN FOR INVENTORY RATE
14	13.2	REVERSE POST RATE
14	12.6	TOTAL NOT MISSION CAPABLE SUPPLY
12	12.2	*NOT-STOCKED BACKORDER RATIO
12	11.8	*INVENTORY EFFECTIVENESS RATIO - (OVERALL)
12	10.6	*UNREPORTED EXCESS INVENTORY RATIO
11	12.0	PERCENT REPAIRABLE THIS STATION (3-LEVEL MX)
11	10.8	INVENTORY ACCURACY (COMPLETED PLUS SPECIAL)
9	9.8	RECEIPT-NOT-DUE-IN RATE
9	9.2	SERVICEABLE BALANCE WITH NO WAREHOUSE LOC

* = denotes indicators developed by the authors.

A t-test using median ratings was used to determine whether the revised indicators were, as a group, statistically better than the original indicators. At a significance level of .05, this test determined that there was sufficient evidence to conclude that the revised indicators are an improvement over the original indicators. The results of the t-test are presented in Table 13.

TABLE 13

T-TEST RESULTS - FIRST VS. SECOND FOCUS GROUP

μ_1	μ_2	s	n	t	t_α	p
10.28	13.67	2.68	5	2.83	2.132	$p \approx .02$

Indicator Validation. Because the revised indicators were statistically better than the original indicators, an attempt was made to validate these findings across the Air Force. Questionnaires were sent to all field grade supply officers at Headquarters Air Combat Command, Air Mobility Command, Air Education and Training Command, Space Command, Air Force Logistics Management Agency, and Systems Service Center. Five questionnaires were sent to field grade supply officers at other offices on Wright-Patterson AFB. Thirty-four questionnaires were sent and 21 were returned for a 61.76 percent return rate, which is comparable with typical return rates for AFIT surveys sent to DOD organizations (Shane, 1993). The results of these questionnaires were used to determine the validity of this research for all MAJCOMs throughout the Air Force. The questionnaire can be found in Appendix G.

Due to different sizes between the focus group and the survey group (5 vs 21), nonparametric statistics were used to compare the results. The researchers ranked the indicators from highest to lowest median, with ties being broken in favor of the highest mean and, if necessary, lowest standard deviation (see Appendices F and H).

Because the average median from the Air Force sample was over two points higher than the focus group (15.8 vs 13.67), a one-tailed Wilcoxon Rank Sum Test, using a significance level of .05, was conducted to determine if the Air Force sample gave higher ratings than the focus group. The result of this test is shown in Table 14, and the rank sums are presented in Table 15. The results support the conclusion that the median ratings from the survey group are statistically different than the median ratings from the focus group.

TABLE 14

WILCOXON RANK SUM TEST - ONE TAILED

T_F	T_S	n	T_L	p
409	257	18	270	$p \approx .007$

TABLE 15

RANK SUMS FOR THE WILCOXON RANK SUM TEST

	Focus Group		Survey Group	
Indicator	Median	Rank	Median	Rank
Unrpt Excess	12	32	14	25
Stock Eff	15	16	18	4
Inv Eff Ratio	12	31	12	30
Issue Eff	15	18	16	13
NMCS Rate	15	19	19	1
TNMCS	14	26	17	7
Rcp-Not-D/I	9	35	14	23
% RTS	11	33	16	15
Inv Acc	11	34	17	8
Srv Bal W/no Loc	9	36	17	9
I/Rs Frozen	14	22	13	28
Time to Clr I/Rs	16	11	14.5	21
Rev Post Rate	14	24	15	17
Whse Ref Rate	15	20	16	10
Bnch Stk Avail	18	6	18	2
Not-Stk B/O	12	29	14	27
Bnch Stk MICAP	18	3	18	5
Supply Cann	16	14	16	12
Total Rank Sum:		409		257

* See Appendix D for full name of indicators.

Five of the six newly developed indicators - Inventory Effectiveness Ratio, Not Stocked Backorder Ratio, Item Records Frozen for Inventory Rate, Time to Clear Frozen Item Records, and Unreported Excess Inventory Ratio - were rated in the bottom six by the survey group. The comments from the survey group indicate that they were uncomfortable with

indicators with which they were not familiar. These same indicators ranked 3rd, 9th, 12th, 13th, and 14th in the second focus group ratings. The results from the survey group imply that the supply managers rated familiar indicators higher than unfamiliar indicators. The mixed ratings from the second focus group can be attributed to the opportunity to discuss the unfamiliar indicators.

The sixth newly developed indicator, Bench Stock MICAP Rate ranked first in the focus group and fourth in the survey group. Even though this is a newly developed indicator, the two components of Bench Stock and MICAP are indicators that are currently used and are familiar to supply officers. In addition to familiarity, this indicator shows customer and mission support as well as indicating potentially serious problems within the supply system.

Once the determination was made that the Air Force ratings were higher than the focus group ratings, the Spearman's Rank Correlation Coefficient was calculated to determine if the focus group and the sample rated the metrics in a similar order. The results of this test are presented in Table 16. R_s is the calculated rank coefficient and R_t is the table value. The squared differences are listed in Table 17. The results of this test support the conclusion that the two groups rated the indicators in a similar order.

TABLE 16

SPEARMAN'S RANK CORRELATION COEFFICIENT

r_s	r_t	n	p
.3994	.399	18	p = .05

TABLE 17

SQUARED DIFFERENCES FOR SPEARMAN'S RANK CORRELATION

Indicator*	Focus Gp Rank	Survey Gp Rank	Diff	$Diff^2$
Unrpt Excess	14	15	-1	1
Stock Eff	5	3	2	4
Inv Eff Ratio	13	18	-5	25
Issue Eff	6	10	-4	16
NMCS Rate	7	1	6	36
TNMCS	11	5	6	36
Rcp-Not-D/I	17	14	3	9
% RTS	15	11	4	16
Inv Acc	16	6	10	100
S Bal W/no Loc	18	7	11	121
I/Rs Frozen	9	17	-8	64
TTC Fzn I/Rs	3	13	-10	100
Rev Post Rate	10	12	-2	4
Whse Ref Rate	8	8	0	0
Bnch Stk Avail	2	2	0	0
Not-Stk B/O	12	16	-4	16
Bnch Stk MICAP	1	4	-3	9
Supply Cann	4	9	-5	25
Sum of $Diff^2$				582

* See Appendix D for full name of indicators.

A visual examination of Table 17 reveals that four of the indicators had significantly different rankings. Item Records Frozen for Inventory Rate and Time to Clear Frozen Item Records were rated much higher by the focus group. This can be attributed to the fact that these two indicators were included in the research primarily due to the comments made in the first focus group meeting. Pride of ownership and the opportunity for discussion might have influenced the higher ratings.

Serviceable Balance with no Warehouse Location was modified to reflect dollar values when presented to the second focus group. The original form of this indicator received a median of 14, whereas the modified form received a median of 11. As mentioned earlier, results of the discussion indicated that this modification was not appropriate. Therefore, the original version was submitted to the survey group.

Inventory Accuracy was one of the three indicators that was not changed between the focus group meetings. It and the other two unchanged indicators, TNMCS Rate and Warehouse Refusal Rate, all scored lower the second time even though the average median increased. This implies that the focus group was rating the indicators relative to the other indicators.

Summary

Based on the results of the two nonparametric tests, the Air Force sample rated the revised indicators higher than the focus group, but in a similar order. These findings add validity to the research and show that these metrics have good potential for Air Force application.

The relationship between the 18 indicators and the Quality-Based Metrics Framework is presented in Table 18. These ratings were given by the authors based on their knowledge of the indicators, a review of the formulas for the indicators, and analyses of the focus group and survey comments. An "S" implies a strong presence, a "W" implies a weak presence, and a "-" indicates no presence of the characteristic in the indicator.

The revised indicators were significantly better than the original indicators. Of the 18 revised indicators, ten were strong in both customer focus and continuous process improvement compared to only two of the original indicators. The other eight revised indicators were strong in either customer focus or continuous process improvement. Ten of the original indicators were strong in neither customer focus nor continuous improvement. Time factors were incorporated in three of the revised indicators versus none of the original indicators. Cost factors were incorporated in 13 of the revised indicators and four were considered to have strong presence. Cost factors only had a strong

presence in one of the original indicators. Overall, there were 34 "S" ratings out of 72 possible (47.22 percent).

TABLE 18

RELATIONSHIP BETWEEN REVISED INDICATORS AND FRAMEWORK

INDICATOR	CF	CI	Time	Cost
Unreported Excess Inv Ratio	-	S	-	S
Stockage Effectiveness (EWS)	S	S	-	W
Inventory Effectiveness Ratio	W	S	-	S
Issue Effectiveness (EWS)	S	S	-	W
Not Mission Capable Supply Rate	S	S	-	-
Total Not Mission Capable Supply	S	S	-	-
Receipt-Not-Due-In Rate	W	S	-	W
% Repairable This Station (3 LM)	S	S	-	W
Inventory Accuracy	W	S	-	S
Serv Balance w/No Warehouse Loc	W	S	-	W
Item Records Frozen for Inv Rate	W	S	W	S
Time to Clear Frozen Item Records	S	S	S	-
Reverse Post Rate	-	S	-	-
Warehouse Refusal Rate	S	S	-	W
Bench Stock Avail (by org)	S	S	-	W
Not-Stocked Backorder Ratio	S	S	-	W
Bench Stock-MICAP Rate	S	S	W	-
Supply Cann Rate	S	S	-	W

V. Conclusions and Recommendations

Overview

This chapter discusses the overall conclusions based on the findings and analysis of the investigative questions presented in the previous chapters. Recommendations are then made for Air Force-wide application for the modified supply metrics and potential use of the quality-based metrics framework throughout the logistics community. Finally, topics are suggested for future research in the area of quality-based metrics in logistics.

Research Conclusions

Conclusion #1. **Ratio data should be used in metrics whenever possible.** Using ratio data in metrics establishes a baseline for comparison between diverse organizations. There may be a great disparity between the workloads of different supply organizations. A small organization may have the fewest rejects overall but have the highest ratio of rejects to inputs. Without using ratios, a false picture of the organizations is presented to the higher commands.

This baseline can also be used internally with other quality improvement tools to strengthen continuous process improvement. Tracking the total number of rejects from month to month will not give a clear indication of efficiency or improvement. If the number of rejects doubles from the previous month but the total number of transactions

triples, then this is an improvement. If ratio data are not used, then this would appear to be a retrogression. Using ratio data would also allow sections to apply other quality improvement tools such as statistical process control.

Conclusion #2. **There is very little consensus among the Air Staff and various MAJCOMs as to which indicators are important.** Only one indicator out of 28 (Bench Stock Availability) was identified by all sources. Out of the 14 indicators identified by AFR 900-14, only two (Inventory Accuracy and Bench Stock Availability) are being reviewed by at least one MAJCOM. Only nine of the 28 indicators are reviewed by more than one MAJCOM. Overall, only ten of the 28 indicators (36%) were identified by more than one source.

MAJCOMs may not be emphasizing the indicators found in AFR 900-14 because they are already being reviewed by Air Staff. However, if an indicator is important to the higher echelons, it should be important to the lower echelons as well. Although the actual missions of the MAJCOMs vary, they are all supported by the SBSS. Therefore, there should be more consensus among the different MAJCOMs as to which indicators are important.

Conclusion #3. **Indicators at all levels should support the strategic goals of the organization.** Different indicators are appropriate at various organizational levels because each organizational level requires unique management

information. Even though most of the data is derived from the same source, different levels within the same organization usually apply the data differently. This appears to correspond with the management philosophies wherein strategic goals require more general information while tactical and operational goals require progressively more specific information (Dixon and others, 1990:166). This conclusion is depicted in Figure 3.

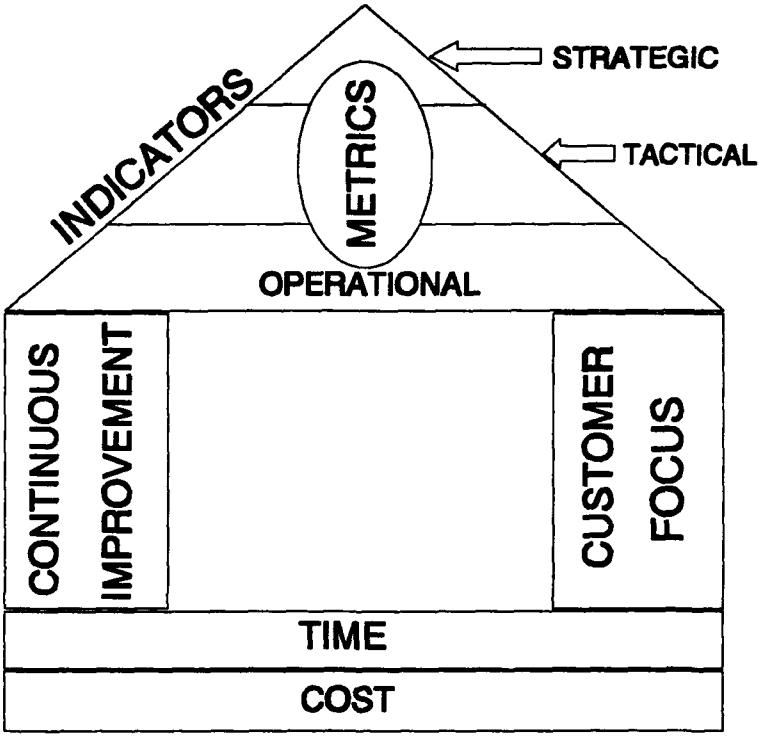


Figure 3. Quality-Based Metrics Framework

The figure above represents a framework on which quality-based metrics should be built. Time and cost are underlying supporting elements for continuous process

improvement and customer focus. Continuous process improvement and customer focus are the major components of quality-based indicators. Indicators exist for all organizational levels. Metrics are a subset of all management indicators. Metrics are meaningful indicators that allow managers to take action and result in process improvement.

Operational goals should support the tactical and strategic goals of the organization. Metrics should be present at every level to link all performance for the attainment of strategic goals (Hall and others, 1991:77; Dixon and others, 1990:72; Williams, 1982:458-461; Szilagyi and Wallace, 1980:336-337).

Conclusion #4. **The characteristics of customer focus and continuous process improvement can be applied to improve current indicators in other logistics areas.** By applying the quality-based metrics framework developed through the literature review, performing content analysis of the comments made by the focus group, and applying ratios wherever appropriate, the original indicators were modified to bring them more in-line with the TQM philosophy. Improvements were verified by having the same focus group rate the revised group of indicators. The revised indicators were significantly better than the original indicators. The results were validated by surveying field grade supply officers throughout the Air Force. The

surveyed officers rated the indicators significantly higher than the focus group, implying potential Air Force-wide application of the quality-based supply metrics.

Although the research applied this framework directly to supply indicators, the literature review indicates that this framework is appropriate across the logistics spectrum. Logistics managers at the different organizational levels (see Figure 3) can apply this framework to their currently used indicators to bring them more in-line with the TQM philosophy.

In a contracting organization, a quality-based indicator might be a ratio of incorrectly processed purchase requests to total number of requests. A transportation metric could be the percentage of requests for vehicles satisfied. Services squadrons could measure customer satisfaction at the various dining facilities. The Quality-Based Metrics Framework is readily evident in many maintenance indicators. An example of a maintenance metric is TNMCM Rate, which is equivalent to the TNMCS Rate. These metrics directly relate to customer focus and can be used to drive continuous improvement.

Conclusion #5. **Many Air Force supply indicators are unnecessary as they do not add value to the supply process or are not linked to strategic goals.** The original focus group meeting determined that the currently used supply indicators, as a group, did not possess the characteristics

of the quality-based metrics framework. This was reflected in the ratings given to the indicators by the focus group. The group rated 9 of the 18 indicators as having a sum median and sum mean of 10 or less out of a possible 20. Only 3 of the 18 indicators had sum means of higher than 15. On the two criteria (customer focus and continuous process improvement) for all 18 indicators, there were a total of 19 individual ratings of 9 or 10 versus 41 ratings of 1 or 2 (see Appendix C).

The authors deleted 6 of the 18 original indicators (33%). These indicators, listed in Table 11, did not have the necessary characteristics required for metrics. As mentioned in the literature review, the Wang Corporation deleted 40% of their indicators when going through a similar process.

Recommendations

Due to the sources of information on the most commonly used indicators, the indicators presented throughout this research are primarily strategic in nature. The revised indicators have numerous potential direct applications.

Recommendation #1. **The researchers recommend that the revised metrics (see Appendix D) be used to replace those measures used in the evaluation of the Air Force Daedalian and Supply Effectiveness awards.** Of the fourteen indicators used as Daedalian Award criteria, ten were rated by the

focus group as having a sum median rating of less than 10. Only two of the modified indicators rated by the same officers had a sum median rating of less than 10; both had sum median ratings of 9. The current measures used in the evaluation for these awards favor smaller organizations with easy-to-maintain weapon systems. The revised metrics establish a fair baseline to compare diverse organizations.

Recommendation #2. **Supply indicators should be revised and incorporated into the M-32.** Although the main focus of this research was on strategic measures, the focus group comments as well as the comments from the surveyed officers indicate that the framework of customer focus and continuous process improvement can be applied to metrics at different levels of management within supply. The following comments from the survey support this recommendation.

> "Your metrics can all be rolled up to the MAJCOMs. I propose there are others [metrics] relevant [only] at the wing level." (Lt Col Johnson, ACC, 1993)

> "Good metrics which inspire the right actions tell our people at all working levels where we want to go and allow us to turn our people loose to get there in their own way." (Col Friel, AFMC, 1993)

A review of all current supply indicators should be conducted. Supply managers should apply the quality-based metrics framework to revise their current indicators. All indicators that cannot be linked to strategic goals or do not add value to the supply process should be eliminated.

The resulting metrics should be incorporated into the M-32 to make it a more useful management tool.

Recommendation #3. In order to foster continuous improvement throughout the Air Force, **the Directorate of Supply at Air Staff should publish a periodic newsletter highlighting success stories in quality improvement**. The newsletter could contain metrics being used by each command and ways that the various bases are applying these metrics for continuous improvement. Accompanying articles could explain how specific metrics support the attainment of strategic goals, which will educate the workers about the relevance of their jobs and make them feel more responsible. This newsletter could be used as a tool for benchmarking by spreading information throughout the supply community.

Recommendation #4. **The authors strongly recommend that Bench Stock MICAP Rate be tracked at all supply units throughout the Air Force**. This metric directly links supply performance to customer satisfaction and mission accomplishment. Bench stock items are relatively inexpensive assets that the customers continually use. Therefore, there is seldom an excuse for supply not having these assets available. If the lack of a bench stock item causes a MICAP, an aircraft is grounded due to poor supply support.

Bench Stock MICAP Rate falls in the category of "new" indicators and had the second highest overall rating between the focus group and the survey group. It was rated the highest by the focus group and second highest by the survey group. This result is significant, considering that the other five "new" indicators were rated in the bottom six by the survey group. The following summary from the second focus group meeting illustrates the usefulness of this indicator:

> Too many times close to fiscal year end, we cut back on bench stock fill to control expenditures. This would give all concerned a measure that could be used to beef up stock on certain bench stock items to preclude the costly MICAPs.
>
> This would be a good way to zero in on problems caused by small items. For want of a bench stock item, the mission wasn't flown. We should not let small dollar value items ground systems or aircraft. This should be very useful in showing how the bench stock items are affecting mission support. (Appendix E)

Recommendation #5. **The revised metrics should be implemented at all MAJCOMs.** Major commands can also use these metrics to compare diverse subordinate supply accounts. Even within the same MAJCOM, wings with similar weapon systems may vary in size. The current indicators favor supply organizations that support smaller wings. By applying ratios to most of the indicators, a common baseline can be developed that is fair to different organizations regardless of resources available.

Recommendation #6. **The revised metrics should be applied at all base supply organizations.** Since metrics drive appropriate actions, Chiefs of Supply could continuously improve by benchmarking those organizations that have the best ratings in these metrics. The previously recommended newsletter would help make this possible. There are numerous other direct applications of these metrics at base level. Supply organizations could apply ratio data, in the forms of Receipt-Not-Due-In Rate, Item Records Frozen for Inventory Rate, Reverse Post Rates, and Bench Stock MICAP Rates, to implement continuous improvement at base level.

Metrics can be used by managers throughout base supply to empower workers. Metrics that are linked to the strategic goals allow all workers to influence the achievement of these strategic goals. Once workers are educated on how their jobs relate to the strategic goals, they become motivated to continuously improve. The relationship between metrics and empowerment can best be explained by the following quote:

> "Good metrics are one of the most, if not the most, effective ways to empower our people. If we do a good job of empowering our people, we take a big step forward in our attempts to create an environment of continuous improvement." (Col Friel, AFMC, 1993)

Recommendation #7. **The authors recommend that a system be developed to track asset flow through the various segments of the logistics pipeline.** The flow of assets

through the Air Force logistics pipeline has been thoroughly studied. Computer technology is available to track assets through the entire pipeline. Successful commercial companies such as UPS and Federal Express can locate an asset anywhere in the pipeline within minutes. The authors had difficulty incorporating time factors into the metrics. This was primarily due to the fact that customer waiting times are not tracked by the supply system. Customer wait times can only be tracked manually.

The only waiting time tracked by the SBSS is the amount of time it takes for base supply to receive their assets from sources of supply. It does not take into consideration whether the assets are required immediately by customers or are for replenishment of stock. The ability to track MICAP assets from source to destination would greatly improve customer and mission support. By being able to track the individual items through the segments, logistics managers could isolate problem areas and attempt to improve those areas.

Recommendation #8. **Implement a retail sales survey.** Using the list of customers who shop at the Base Service Store, the Tool Issue Center, or the Individual Equipment Section, the Retail Sales Section of base supply should send out a monthly customer satisfaction survey. The questionnaire should contain questions which reflect levels of customer support, with a score of 1 implying poor

customer service and a score of 5 indicating excellent customer service. This information could be fed back to the workers to drive continuous improvement and improve customer support.

Suggestions for Further Research

This research uncovered areas that should be investigated further. Although Total Quality Management is not a new philosophy, application of TQM in the area of logistics, and especially in logistics metrics, is still in its infancy. Developing metrics that support TQM requires looking at logistics organizations from a different perspective than traditional management philosophies.

Suggestion #1. **Research should be conducted to develop, verify, and validate metrics in other logistics areas.** The literature review indicates that the Quality-Based Metrics Framework developed in this research can translate to other logistics functions. Therefore, similar studies should be conducted using focus groups to apply this framework and develop metrics for Transportation, Maintenance, Logistics Plans, Contracting, and Services. A stronger validation could be conducted by incorporating ratings and comments from overseas MAJCOMs.

Suggestion #2. **Develop metrics for base supply.** Current supply indicators at all organizational levels

(operational, tactical, and strategic) should be examined and the Quality-Based Metrics Framework applied to develop distinctive metrics for each of the respective levels. Metrics could be developed for each section within the supply organization to link lower-level performance with strategic goals. The revised indicators developed in this research could be broken down into useful metrics at the COS and individual section levels. An example is Warehouse Refusal Rate. The total number of warehouse refusals would be useful to the COS for indication of training effectiveness, while individual warehouse refusals by location would be useful to the section supervisor to identify specific individuals requiring training.

Suggestion #3. **Conduct a case study concerning implementation of the revised metrics.** This study could apply revised metrics to several supply organizations in the various MAJCOMs and track their performance over a period of time, verifying whether the metrics drive continuous improvement in an actual work environment. This study could result in a revised set of metrics and also determine which metrics work and which do not. This study could also investigate how the metrics help empower the workers and drive the appropriate behavior.

Summary

This research developed the Quality-Based Metrics Framework, which consists of customer focus and continuous process improvement with the underlying supporting elements of time and cost. A review of pertinent Air Force publications and interviews with supply analysts at CONUS MAJCOMs identified the most commonly used supply indicators. This list contains all indicators included in the Daedalian/ Supply Effectiveness Award criteria and other indicators regularly reviewed by more than one CONUS MAJCOM. These indicators were found to be of little use to base-level supply officers. The original indicators were then modified to bring them more in-line with the TQM philosophy.

Supply management indicators have remained unchanged since the implementation of TQM and metrics in the Air Force. Metrics are one of the most important tools that a manager has to improve the quality of the organization. Metrics drive process improvement, link lower level performance to strategic goals, and can even empower workers. Proper application of revised metrics throughout the Air Force and the Department of Defense can dramatically improve the achievement of national defense goals.

Air Force Materiel Command (AFMC) is a leader in the implementation of metrics in the Air Force. The command's sponsorship and application of this research reflects the importance of metrics. Customer focus and continuous process improvement directly relate to the first, second,

fourth, and fifth AFMC goals of (1) satisfying customer needs in war and peace; (2) enabling people to excel; (3) sustaining technological superiority; (4) enhancing the excellence of business practices; and (5) operating quality installations (Hinneburg, AFMC, 1991). Implementation of these metrics is a way to assess achievement of AFMC's strategic goals.

If the Air Force supply community is to be successful in realizing the highest possible degree of quality improvement, supply indicators must be geared towards continuous quality improvement rather than just meeting the minimum goals. As General McPeak stated in his video "Two Kinds of Change," the style of the new Air Force is **Quality Air Force** and our credo is: "A leadership commitment and operating style that inspires trust, teamwork and **continuous improvement**..."(McPeak, 1992).

Appendix A: Supply Management Indicators

GENERAL INFORMATION

The supply management indicators presented to the focus group are listed below along with the formulas used to equate the indicators. The formulas were found in AFM 67-1 and AFR 900-14 and associated documents.

1 - **STOCKAGE EFFECTIVENESS** - (OVERALL)

$$\frac{\textit{No. Units Issued}}{\textit{No. Units Issued + No. Units B/O - No. Units B/O 4W}}$$

2 - **ISSUE EFFECTIVENESS** - (OVERALL)

$$\frac{\textit{No. Units Issued}}{\textit{No. Units Issued + No. Units B/O}}$$

3 - **BENCH STOCK AVAILABILITY**

$$\frac{\textit{Total Line Items Authorized - Line Items Due-out}}{\textit{Total Line Items Authorized}}$$

4 - **STOCKAGE EFFECTIVENESS** - (PRIMARY WEAPON SYSTEM)

$$\frac{\textit{No. PWS Units Issued}}{\textit{No. PWS Units Issued + No. PWS Units B/O - No. PWS Units B/O}}$$

5 - **MISSION CAPABLE RATE**

$$\frac{\textit{NMCM + NMCS + NMCB Hours}}{\textit{Total Possessed Hours}}$$

6 - **TOTAL NOT MISSION CAPABLE SUPPLY**

$$\frac{\textit{NMCS + NMCB Hours}}{\textit{Total Possessed Hours}}$$

7 - **RECOVERABLE/CONSUMABLE STOCKAGE EFFECTIVENESS**

$$\frac{\textit{Rec Units Issued}}{\textit{Rec Units Issued + Rec Units B/O - Rec Units B/O 4W}}$$

$$\frac{\textit{Cons Units Issued}}{\textit{Cons Units Issued + Cons Units B/O - Cons Units B/O 4W}}$$

8 - **RECOVERABLE/CONSUMABLE ISSUE EFFECTIVENESS**

$$\frac{\textit{Rec Units Issued}}{\textit{Rec WS Units Issued + Rec WS Units B/O}}$$

$$\frac{\textit{Cons Units Issued}}{\textit{Cons WS Units Issued + Cons WS Units B/O}}$$

9 - **RECEIPT-NOT-DUE-IN RATE**

Total Shipments Received With No Corresponding Due-in

10 -**PERCENT REPAIRABLE THIS STATION** (OVERALL)

$$\frac{\textit{Number of Units Repairable This Station}}{\textit{No. Units RTS + No. Units NRTS + No. Units Cond}}$$

11 - **INVENTORY ACCURACY** (COMPLETED PLUS SPECIAL)

$$1 - \frac{\textit{Total Units Over + Short}}{\textit{Total Record Balance}}$$

12 - **RELEVELING FREQUENCY**

No. Completed with Date of Last Transaction

13 - **FOLLOW-UP FREQUENCY**

No. Completed with Date of Last Transaction

14 - **SERVICEABLE BALANCE WITH NO WAREHOUSE LOCATION**

$$\frac{\textit{Numer of Item Records With Serv Bal and No Whse Location}}{\textit{Total Number of Item Records}}$$

15 - **ITEM RECORDS PAST DUE INVENTORY**

$$\frac{\textit{Total Item Records Past Due Inventory}}{\textit{Total Item Records}}$$

16 - **SYSTEM/GENERAL SUPPORT DIVISION (SSD & GSD) STOCKAGE EFFECTIVENESS**

$$\frac{\textit{No. SSD Units Issued}}{\textit{No. SSD Units Iss + No. SSD Units B/O - No. SSD Units B/O 4W}}$$

$$\frac{\textit{No. GSD Units Issued}}{\textit{No. GSD Units Iss + No. GSD Units B/O - No. GSD Units B/O 4W}}$$

17 - **SYSTEM/GENERAL SUPPORT DIVISION (SSD & GSD) ISSUE EFFECTIVENESS**

$$\frac{\textit{No. SSD Units Issued}}{\textit{No. SSD Units Issued + No. SSD Units B/O-}}$$

$$\frac{\textit{No. GSD Units Issued}}{\textit{No. GSD Units Issued + No. GSD Units B/O-}}$$

18 - **WAREHOUSE REFUSAL RATE**

$$\frac{\textit{Total Number of Warehouse Refusals}}{\textit{Total Number of Issues}}$$

Appendix B: Comments From First Focus Group

1. STOCKAGE EFFECTIVENESS - (OVERALL)

Need to track trends over a two year period. An effective metric of how well we keep what we're authorized on the shelf. Doesn't account for those things our customer asks for that we don't have levels for. Those are important, too.

I like this indicator, but you have to have a good feel for what you have and don't have.

This indicator is nice to know, however base level managers have little control.

A primary evaluation tool of any base supply organization. Dependent on depot support - creates lots of manual work for supply personnel as part of follow-up.

If we were truly responsive and customer oriented, we would refuse to make ourselves better by excluding the 4W B/Os. While we don't have crystal balls to project what the customer wants and needs, the current formula allows us to artificially inflate how well we're doing.

2. ISSUE EFFECTIVENESS - (OVERALL)

If it isn't stocked, you can't win with this one.

This tells the customer what he needs to know - we ought to be more interested than we have been. Using only stockage effectiveness lets us hide behind the "we aren't authorized this" syndrome. The customer doesn't care whether we are auth a level or not. He needs his stuff.

My feeling is this is worthless. Too easy to manipulate. This is currently being misused by COSs who push "numbers" in an effort to make their accounts more competitive.

This can provide you with information regarding how well you anticipate customer requirements. Since the supply system is reactive to demands rather than proactive, this indicator should not be used to judge effectiveness.

Hope the customer ask for the right thing. Doesn't keep up with the rapid changes that customers are experiencing.

Again, this should be measured as weapon system dependent.

3. BENCH STOCK AVAILABILITY

Unfortunately, we tend to hide behind Computer generated authorizations in lieu of what the customer really needs on his account. Even if we do add to the B/S account often we don't stock adequate quantities in supply to ensure timely fill of depleted B/S.

Agree this is important to the customer. Must be used to drive follow-up behavior in stock control. My experience is that customers complain more quickly about bench stock than anything else if support isn't good. Must mean they think it is important.

Maintenance tends to put many things on Bench Stock that aren't really needed, and may not be used much. Just because we have a lot of those things in stock doesn't tell us how well we are supporting the customer. If we measured this BY ORG, we would probably learn that this measure is more valid for some orgs than others because some have what they SHOULD have on bench stock, and others don't.

Great indicator for your Bench Stock supervisor. However, the senior supply managers don't need this indicator. The COS might want to survey bench stock customers for service satisfaction ratings.

Good indicator for supply because its always high. Bench stock still confusing to many customers. Manually manipulated near end of year to spend or save money.

4. STOCKAGE EFFECTIVENESS (PRIMARY WEAPON SYSTEM)

Important measure of level of support. Fiscal constraints prevent continuous improvement past a certain point. Also, the leveling formula limits stockage past a certain level. We measure ourselves on this one. Our customers measure us more on issue effectiveness.

Agree this is important measure. However, one comment indicated that the customer is more concerned with Issue Effectiveness. May be true, but I believe this is an invalid measure unless it is used internally by managers who not only know what they are doing, but are unwilling to lie to themselves.

Good indicator when only one weapon system existed at a base. When more than one exists, creates conflicting priorities.

Maybe there should be stockage effectiveness levels for OLD and NEW weapons systems at any given installation. A COS who has had a system loaded for 10 years should show a better rate that if s/he had a year old system. Perhaps 4Ws would be useful for NEW systems vice OLD.

Need to look at Stockage Effectiveness BY WEAPON SYSTEM, not overall, if there is more than one primary weapon system on a base. Particularly true for objective wings which support numerous weapon systems.

If authorized to stock item, and sufficient funding is available, and if depot managers are keeping stocks on hand, and if contracting folks don't drop the ball in the acquisition process, etc... Supply managers at base level have little control...Good feeder information for top level policy makers, not a valid base level measure.

5. MISSION CAPABLE RATE

Top level metric for Wing/CC. Our piece of the pie is TNMCS. Aircraft availability drives most of our newer systems, like DRIVE, so we need to watch this one.

The indicator of supply effectiveness that receives daily attention. Greatly simplified with the creation of the mass system. Very dependent of the whims of item managers.

I have seen collusion between Chiefs of Maintenance and Supply on this one, especially when either trying for Daedalian awards.

MICAP rates can be deceiving. Must be used carefully by the COS. Unfortunately, others, like the Wg/CC may use it to drive nails into the COS. I believe the MICAP rate can be used effectively by COS for the internal management of his MICAP section.

A good indicator that needs to be further broken down. Supply is responsible for transportation activities and picks up this effect in NMCS Supply time. Need to hold each activity responsible for its own actions.

The comment about collusion between Chief of MX and COS may be valid, but this whole concern about collusion at any level to "make the numbers right" tells us something about the 900-14 criteria for winning awards, doesn't it.

While NMCS rates drive a desire to "place blame," this, in itself, may not be all bad, even though it may seem so. If

it results in shortened intransit times, or improved procedures, then it may be worth the pain.

6. TOTAL NOT MISSION CAPABLE SUPPLY

Shared blame - really should be a supply indicator. This is a tough one to call.

Best indicator of part of the NMC rate supply is responsible for. To hide behind maintenance when they are working on the system doesn't get the part any faster.

Policy changes are underway which will no longer allow IMs to hold parts for MICAPS only. There's good evidence, and MAJCOMS generally agree, that mission capability is better when all the parts are in the field and we let the bases redistribute with MASS. IMs have been conditioned not to do this, so it will take time to teach new behavior.

Indicator is deceiving. Total NMCS includes base level supply processing time, transportation time, and depot response time. For the base level supply manager, this provides an opportunity to get beaten up for actions your not responsible for. Break this indicator into its component parts and give a better perspective.

To me, this blurs the playing field. The more variables that are included in the formula, the harder it is to determine what's really happening and hence, how to control the outcome.

I like this one better than the mission capable rate alone.

7. RECOVERABLE (CONSUMABLE) STOCKAGE EFFECTIVENESS

Maybe taking the stockage effectiveness down to a level that is so narrow that it carries little weight.

This is another in the continuing saga of stockage effectiveness. Best to leave this indicator in the capable hands of your stock control supervisor.

Will be trending down for everyone because of RSD funding. We can only buy, at most, 65% of condemnations. $ available for repair are also dependent on sales. Customers will be buying what helps them the most, not necessarily what we

have for sale. Supply should watch this as a leading indicator of the effect of RSD.

While this measure should be a good indicator as to how we are doing under RSD- it will be more and more difficult to manage at the base level.

When put on the firing line with a superior, it's nice to be able to point fingers elsewhere. Knowing these two different figures at least gives me a pointer where to concentrate. Useless otherwise for COS.

8. RECOVERABLE (CONSUMABLE) ISSUE EFFECTIVENESS

Do we really need to work at this level?

Same comments apply here as for overall issue effectiveness.

The customer asks for what he needs, not what we have.

How far must this be carried out?

It's going to hard enough to work effectively with Consumable Stockage Effectiveness under RSD without having to try to figure out how meaningful the Issue Effectiveness is with all of its own foibles (similar to overall issue effectiveness).

9. RECEIPT-NOT-DUE-IN RATE

Good indicator of possible larger problems - good basis for additional research.

Useful as a rate tracked over time. Best used internally as indicator of system integrity. I have been in accounts where rate was so low, branch chiefs could explain each one as a justifiable anomaly. Must be careful not to make receipts not due in "illegal" and start shooting messengers. If we treat people right they won't game the system.

Push levels from item managers/MAJCOM staff requirements. Faulty stock control management. Customer canceling requirements. Any number of reasons could cause this. Occurrences and trends, I LOOK AT.

This tells you if requisitions are being canceled far into the process of gaining depot responses. Never a big

problem. May best be expressed as a ratio of total receipts!

This has never seemed to be a big problem, but it should be tracked by Stock Control. Not sure how this will or will not be affected by RSD.

10. PERCENT REPAIRABLE THIS STATION (OVERALL)

This indicator only tells one that a reasonable repair capability does or doesn't exist at a base. Without further breakdown, which Ch of Maintenance records show, it is not a good indicator for probability of repair at the location for the particular problem the item has. It only indicates to supply that they should investigate further. Not necessarily a bad feature. Does it support the customer better? Probably not, if customer has already explored the possibility of repair, which usually is a pre-supply process step.

Under 2 Level MX, this is becoming more and more meaningless. However, for those systems which are still 3 Level, I really like this one. I compare this number to other bases with like weapon systems and work with MX to upgrade capabilities.

An indicator that has seen its day with the introduction of two level maintenance.

Two level only applies to avionics and engines at this point and not all of those. There will still be a lot of three level maintenance at base level for several years.

A feature of your maintenance community. Supply is only one vehicle through which this data can be derived. Maintenance data bases provide a much more realistic measure of repair capability by both weapon system and maintenance shop activity. Job order/Work order specific data is available through CAMS.

This becomes another Source of Supply that can make or break a wing.

Great to compare supply rates to those maintenance rates for determining if the required updates of maintenance actions occurred in the supply demand data base.

11. INVENTORY ACCURACY (COMPLETED PLUS SPECIAL)

This is probably one of the best metrics for continuous improvement available. I have seen accounts move up 15 or 20 percent over five or six years by continuously working the whole system to improve accountability. Accountability for the taxpayer's money, next to customer support, is our most important task.

We count it but we really don't do any thing with it. A very frustrating indicator because it makes inventory look like the bad guys.

Important to internal control of base supply assets. The COS must remain sensitive to the fact that this can be manipulated by a collusion between his inventory and warehouse people. Can be valuable though to identify internal problems.

This indicator provides an opportunity to improve our accountability. By examining each subprocess that leads to carrying an item in-stock, we can further the trust of American taxpayers.

I like this one. Gives me a measure of warehouse efficiency and effectiveness in day-to-day work. Good basic indicator for COS.

12. RELEVELING FREQUENCY

Something to watch, but not a metric. Generally close to 100% of days available in my recent experience. In the old days of 1050-II, this was more important because of down time, etc. Given current system reliability, you can make this a matter of policy.

This is an area that needs work. Supply excess is growing all the time due to auto releveling.

I think this is important, if for nothing else but to ensure it is being done when it's supposed to be. Once you are sure this is being done frequently enough, it may be even more important to look at the relationship between the COS computer room and the base communications people. Under the new system where Comm has the mainframe computer, it is EXTREMELY important that supply requisitions are sent off base in a timely and accurate manner. (We are finding this is not being done in all cases, and that there is a significant learning process involved.)

Can be releveled too frequently say at 75% of stock authorized instead of 50%. Can cause too much stock, too frequent ordering (wasted Transportation $$), etc. Helps stockage effectiveness numbers.

More a matter of policy than an indicator to facilitate improvement.

13. FOLLOW-UP FREQUENCY

Same comment as releveling frequency. Set a policy. System reliability will do the rest.

Does this do any good? No one is paying any attention to it because they don't see results.

Similar to the previous category. Make this a matter of policy.

Why overload the system with meaningless extra work? Standards are set, use them. If someone is trying to use THIS as a metric, then they're way off base. It only indicates how often START was pushed by the computer operator, not how well stock control or any other unit in supply is doing.

This is important only if:
- you are sure that the information you are getting back is accurate (not always the case)
- you know what to do to correct the situation WHEN (not if) you find that your requisitions aren't being handled properly.

14. SERVICEABLE BALANCE WITH NO WAREHOUSE LOCATION

An important lower tier metric supporting inventory accuracy. The warehousing function needs this to be sure they are assigning locations to items stored, which a first principle of accountability.

This one used to drive me crazy and I never did get a good explanation as to why it happened.

A good metric for your storage and distribution function. In times past, this was more or less a determinant of when the program was run rather than an indicator of vast amounts of misplaced stock.

Why, why, why? Not a major indicator, may point to problemsin the warehouse. Definitely becomes a problem if there's a MICAP hit against one of these no location items.

Can be useful in making sure the warehouse people are doing what they are supposed to be doing. The answers to the "why" questions as they pertain to this issue can be confusing, though. Again, this is useful for internal control by supply management.

15. ITEM RECORDS PAST DUE INVENTORY

A good sub metric for the inventory section. Ought to approach zero over time. If the numbers or rate are high, there's a problem.

Kept inventory on their toes but didn't do much to improve supply support.

Good metric for the Inventory Section supervisor. Does little to indicate quality of supply support at any higher level.

This should happen infrequently if a good annual inventory plan exists. Special, special, special reasons only for going past inventory date. Otherwise, I've got problems. Could affect the customer, but usually doesn't. I/Rs frozen for inventory more likely to affect customer temporarily, but should be able to be worked around.

This used to be managed very strictly, but nowadays, as manpower becomes more and more reduced, people are looking at this more openly. It isn't as important to inventory some items as others, and this is being recognized at all levels. Policies are changing to accommodate. At the same time, it will be more difficult for the COS to determine if his inventory people are or are not doing their jobs if different items are subject to different rules. This is still necessary and important.

16. SYSTEM/GENERAL SUPPORT DIVISION (SSD & GSD) STOCKAGE EFFECTIVENESS

Same comments as on other stockage indicators

Stock rated to death.

Enough is enough!

While this is an unpopular indicator (I don't like it either), it may become more important under RSD. I would not like to see it done away with until our systems become more well-grounded in the effects of RSD.

17. SYSTEM/GENERAL SUPPORT DIVISION (SSD & GSD) ISSUE EFFECTIVENESS

Same as other issue effectiveness indicators.

Another item in the long list of issue effectiveness rates.

Often used to explain "Overall" numbers.

Same comments for SSD/GSD Stockage Effectiveness, except for the fact that I generally hate issue effectiveness rates for the reasons I have mentioned earlier -- namely that they are too easily manipulated, and the fact that there are too many toads out there willing to do the manipulating.

18. WAREHOUSE REFUSAL RATE

Very important leading metric of inventory accuracy. Can, if managed with integrity, approach zero over time. I have seen warehouses go for months without a refusal. In the vein of continuous improvement, when the numbers get low, they can usually be explained individually. Sometimes it takes years to get to that point, because inventory accuracy must be high before the refusal rate approaches zero.

A number so small that it warrants little attention until it goes totally out of specs.

This approaches zero. To pursue continuous improvement, this measurement should change to reflect individual incidents. Improvements found by slicing through the processes that caused the refusal and tracing down the origin of the problem.

Agree that it is a part of inventory accuracy. But it isn't the whole ball game. Taken with serviceable balance w/no location and RVPs and their reasons, over time, COS has a good feel for what's truly happening. This is an indicator of NON-customer support. We didn't give him the item,

although we promised and lost valuable time either in inventory or backordering.

I liked this indicator as a COS, not because of the low numbers ordinarily associated with it, but it gave me reason to "peel the onion" so to speak, and delve deeper into why things were or were not happening in the warehouse. Again, this is one which MUST be handled carefully and with integrity because of the ease with which a slick superintendent can slide over and around the real reasons for problems in this area.

19. GENERAL COMMENTS

I believe the Reverse Post rates are one of the most important indicator available to the COS. Training requirements, DIREP identification, etc., etc., etc. SUPER IMPORTANT!

Let's add reverse post rates! Tells COS of training problems, system difficulties, and coordination problems.

Suggest Reverse Post rate be included as an internal supply metric to drive training needs, system anomalies, etc.

Develop a survey that would indicate satisfaction levels of customer service. Each supply customer organization would periodically get the opportunity to express thoughts on the responsiveness of supply support, personal attention, and problem solving efficiency. Use statistical analysis to determine areas where increased awareness might be necessary.

Base Supply must face the harsh reality that it can no longer support every customer request off the shelf. It needs to look at ways to improve customer support even if it means taking supply out of the process.

Management products are geared to evaluate the base supply system by the numbers, it does not look at innovative ways to make the system better.

To go along with the management products, there should be an answer sheet that gives workers possible solution to improve the process.

The financial world will dominate further supply operations, but it is the most confusing aspect of the entire base supply system.

Excess management should be a management product

While not perfect by any means, M32 data provides COS and staff valuable insights into the account. As stated by one participant, the data can be used by all concerned for learning purposes. Few of these indicators were derived to indicate positive/negative customer support trends. In the world of TQM, few of the supply indicators drive actual process improvements - they are after-the-process inspection points, not mid-cycle check points for process health. In fact, by the time, negative trends develop, you might as well carry it all in a hand basket.

I, and a lot of others I have talked with lately, have some real problems with the way the Air Force level awards are determined. The emphasis has always been on either numbers or a combination of numbers and self improvement efforts. The past two years, "numbers" has been the bugaboo. It is much easier for a base with a high density fleet to compete based on numbers. This effectively eliminates all bases which, although they may have an extremely good operation, just can't make it due to a low density fleet, experimental aircraft which notoriously have a large amount of down time, etc. I believe that any future efforts to come up with "meaningful measures of merit" should be geared to JUST THAT. How do you measure a wing to see if they are REALLY doing a good job, or if they are merely blowing smoke? Or, how do you effectively compare low and high density orgs?

I think that there may need to be two types of measurement tools available to the COS -- one which he can use internally that will mean something to "the non-manipulative manager," and another which can be used to numerically rate mission-diverse organizations.

I/Rs frozen for inventory might be a viable measure of non-customer support, provided it was compiled more frequently than monthly, and most management levels of Supply looked at routinely.

NOTES FROM OPEN DISCUSSION

#1
- computer determines levels
- doesn't tell how well we support our customer
- doesn't show movement of supplies
- good data for very senior MAJCOM officials
- base level no control
- funding driven
- dead item records kept for manning, drops s/e

#2 - combine i/e and s/e on same chart = much better
- need a proactive measure
- potential good internal measure
- manipulation = integrity problem
- loosing customers because of "competition"

#3 - bench stock is confusing for customers
- obligation authority
- currently buying 65% rsd (58% ssd) condemnations
- used for "horn tooting" for supply
- service rating might be better than availability
- money is first restricted on bench stock when funds become tight and first to be spent when money becomes available

#4 - much better than #1
- take care of critical customers
- take away/change the 85% goal imposed by MAJCOMs
- effected by funding and reduced # of airframes
- what level of activity is needed to support wartime capability
- distinguish between weapon systems
- rsd 'sale' is pushed as opposed to 'stock'

#5 - controlled by item managers who want to hoard parts, thereby creating MICAPs

#6 - truer than #5
- break it down into component parts to improve the process
- what about transportation time?
- mode of transportation is not really important, just when it will arrive
- clean it up a little
- difficult to track trans between many different commercial carriers

#7 - many of these type indicators are very good for internal training

#8 - ditto

#9 - ratio - ratio - ratio
- #s so small that you have to look for spikes, anomalies
- useful
- shows where training is needed
- defense programs sometimes are factors

#10 - repairs at base level will still be around for awhile
- this is tracked by supply because of ability to track
- use as a probe to compare with other bases
- no control

- less specialization makes overlap important in logistics
- systems perspective
- demand history is told by this indicators

#11 - can be made to appear misleading
- any # generated by a system can be manipulated (even this)

#12 -linked to s/e (overall)
- automatically done by the computer, too often overworks and overstocks stuff
- SIFS
- communication with COMM/teamwork

#13 - similar to #12
- must be used intelligently to determine if there's a problem at a depot
- good to be used in analysis of results, not just follow-up frequency
- use by depot/im/system

#14 - system and quirk controlled
- good internal measure

#15 - good internal measure
- still necessary and important internally
- i/r frozen for inventory relates to customer support

#18 - well liked by participants
- good indicator of poor customer support
- can be manipulated by a "slick" superintendent

#19 - reverse posts!!!
- $$$
- ex post facto
- need measures comparable between different types of bases, different commands, and different fleets
- limit the indicator that are difficult to manipulate
- don't let metric be used as a hammer

Appendix C: Ratings From First Focus Group

>> Equally Weighted Criteria (Text Report) <<

Median	Mean	** ALTERNATIVES **
17	16.4	WAREHOUSE REFUSAL RATE
16	16.0	TOTAL NOT MISSION CAPABLE SUPPLY
15	14.0	BENCH STOCK AVAILABILITY
14	14.6	STOCKAGE EFFECTIVENESS (PRIMARY WEAPON SYSTEM)
14	12.8	INVENTORY ACCURACY (COMPLETED PLUS SPECIAL)
13	11.0	STOCKAGE EFFECTIVENESS - (OVERALL)
12	13.0	MISSION CAPABLE RATE
12	12.4	ISSUE EFFECTIVENESS - (OVERALL)
11	9.4	SERVICEABLE BALANCE WITH NO WAREHOUSE LOCATION
10	9.6	ITEM RECORDS PAST DUE INVENTORY
10	9.2	PERCENT REPAIRABLE THIS STATION (OVERALL)
8	9.0	RECEIPT-NOT-DUE-IN RATE
7	7.8	RECOVERABLE (CONSUMABLE) STOCKAGE EFFECTIVENESS
6	7.0	SSD/GSD STOCKAGE EFFECTIVENESS
6	6.8	SSD/GSD ISSUE EFFECTIVENESS
5	7.6	RECOVERABLE (CONSUMABLE) ISSUE EFFECTIVENESS
4	5.8	RELEVELING FREQUENCY
4	4.4	FOLLOW-UP FREQUENCY

>> Criteria Matrix <<

1. How well does this indicator reflect customer/mission support?

	Participant Ratings														
** Alternative **	1	2	3	4	5	6	7	8	9	10	N	n	MN	STD	MED
STOCKAGE EFFECTIVENE	-	-	-	-	2	-	2	1	-	-	5	5	6.4	1.34	7
ISSUE EFFECTIVENESS	-	-	-	-	1	1	1	-	2	-	5	5	7.2	1.79	7
BENCH STOCK AVAILABI	-	-	1	-	-	-	1	3	-	-	5	5	6.8	2.17	8
STOCKAGE EFFECTIVENE	-	-	-	-	1	-	-	2	2	-	5	5	7.8	1.64	8
MISSION CAPABLE RATE	-	-	-	-	1	-	2	1	1	-	5	5	7.2	1.48	7
TOTAL NOT MISSION CA	-	-	-	-	-	-	1	3	1	-	5	5	8.0	0.71	8
RECOV/CONS STK EFFEC	-	1	2	1	-	-	-	1	-	-	5	5	4.0	2.35	3
RECOV/CONS ISSUE EFF	-	1	2	1	-	-	-	1	-	-	5	5	4.0	2.35	3
RECEIPT-NOT-DUE-IN	-	1	2	2	-	-	-	-	-	-	5	5	3.2	0.84	3
PERCENT REPAIRABLE	-	1	1	-	2	-	-	1	-	-	5	5	4.6	2.30	5
INVENTORY ACCURACY	-	1	-	1	-	-	2	-	-	1	5	5	6.0	3.08	7
RELEVELING FREQUENCY	1	2	1	1	-	-	-	-	-	-	5	5	2.4	1.14	2
FOLLOW-UP FREQUENCY	1	3	-	1	-	-	-	-	-	-	5	5	2.2	1.10	2
SERVICEABLE BALANCE	-	2	-	-	2	1	-	-	-	-	5	5	4.0	1.87	5
ITEM RECORDS PAST DUE	-	2	1	-	1	-	1	-	-	-	5	5	3.8	2.17	3
SSD/GSD STOCK EFF	-	1	1	2	-	1	-	-	-	-	5	5	3.8	1.48	4
SSD/GSD ISSUE EFF	-	1	2	-	1	1	-	-	-	-	5	5	3.8	1.64	3
WAREHOUSE REFUSAL	-	-	-	-	1	-	-	1	2	1	5	5	8.2	1.92	9

2. How well does this indicator lead you to continually improve the process

** Alternative **	Participant Ratings 1	2	3	4	5	6	7	8	9	10	N	n	MN	STD	MED
STOCKAGE EFFECTIVENE	1	1	-	-	-	1	2	-	-	-	5	5	4.6	2.88	6
ISSUE EFFECTIVENESS	-	1	1	-	1	-	1	-	1	-	5	5	5.2	2.86	5
BENCH STOCK AVAILABIL	-	-	-	-	-	1	2	2	-	-	5	5	7.2	0.84	7
STOCKAGE EFFECTIVENE	-	-	-	-	1	2	-	1	1	-	5	5	6.8	1.64	6
MISSION CAPABLE RATE	-	-	1	-	2	-	1	-	1	-	5	5	5.8	2.28	5
TOTAL NOT MISSION CAP	-	-	-	-	-	-	1	3	1	-	5	5	8.0	0.71	8
RECOV/CONS STOCK EFF	-	2	-	2	-	-	1	-	-	-	5	5	3.8	2.05	4
RECOV/CONS ISSUE EFF	-	2	1	1	-	-	1	-	-	-	5	5	3.6	1.85	3
RECEIPT-NOT-DUE-IN	-	1	-	-	2	-	1	-	-	1	5	5	5.8	2.95	5
PERCENT REPAIRABLE	1	1	-	-	1	1	-	-	1	-	5	5	4.6	3.21	5
INVENTORY ACCURACY	-	-	1	-	-	1	-	2	1	-	5	5	6.8	2.39	8
RELEVELING FREQUENCY	2	1	-	1	-	-	-	-	1	-	5	5	3.4	3.36	2
FOLLOW-UP FREQUENCY	2	1	1	1	-	-	-	-	-	-	5	5	2.2	1.30	2
SERVICEABLE BALANCE	-	-	1	1	-	1	2	-	-	-	5	5	5.4	1.82	6
ITEM RECORDS PAST DUE	-	-	1	-	1	-	3	-	-	-	5	5	5.8	1.79	7
SSD/GSD STOCK EFF	-	3	-	1	-	1	-	-	-	-	5	5	3.2	1.79	2
SSD/GSD ISSUE EFF	-	3	1	-	-	1	-	-	-	-	5	5	3.0	1.73	3
WAREHOUSE REFUSAL	-	-	-	-	-	-	1	3	-	1	5	5	8.2	1.10	8

>> Alternative Matrix <<

1. STOCKAGE EFFECTIVENESS - (OVERALL)

** Criteria **	Participant Ratings 1	2	3	4	5	6	7	8	9	10	N	n	MN	STD	MD
Customer/Mission Focus	-	-	-	-	2	-	2	1	-	-	5	5	6.40	1.34	7.00
Continuous Process Impro	1	1	-	-	-	1	2	-	-	-	5	5	4.60	2.88	6.00

2. ISSUE EFFECTIVENESS - (OVERALL)

** Criteria **	Participant Ratings 1	2	3	4	5	6	7	8	9	10	N	n	MN	STD	MD
Customer/Mission Focus	-	-	-	-	1	1	1	-	2	-	5	5	7.20	1.79	7.00
Continuous Process Impro	-	1	1	-	1	-	1	-	1	-	5	5	5.20	2.86	5.00

3. BENCH STOCK AVAILABILITY

** Criteria **	Participant Ratings 1	2	3	4	5	6	7	8	9	10	N	n	MN	STD	MD
Customer/Mission Focus	-	-	1	-	-	-	1	3	-	-	5	5	6.80	2.17	8.00
Continuous Process Impro	-	-	-	-	-	1	2	2	-	-	5	5	7.20	0.84	7.00

4. STOCKAGE EFFECTIVENESS (PRIMARY WEAPON SYSTEM)

** Criteria **	Participant Ratings 1	2	3	4	5	6	7	8	9	10	N	n	MN	STD	MD
Customer/Mission Focus	-	-	-	-	1	-	-	2	2	-	5	5	7.80	1.64	8.00
Continuous Process Impro	-	-	-	-	1	2	-	1	1	-	5	5	6.80	1.64	6.00

5. MISSION CAPABLE RATE

** Criteria **	Participant Ratings 1	2	3	4	5	6	7	8	9	10	N	n	MN	STD	MD
Customer/Mission Focus	-	-	-	-	1	-	2	1	1	-	5	5	7.20	1.48	7.00
Continuous Process Impro	-	-	1	-	2	-	1	-	1	-	5	5	5.80	2.28	5.00

6. TOTAL NOT MISSION CAPABLE SUPPLY

** Criteria **	Participant Ratings 1	2	3	4	5	6	7	8	9	10	N	n	MN	STD	MD
Customer/Mission Focus	-	-	-	-	-	-	1	3	1	-	5	5	8.00	0.71	8.00
Continuous Process Impro	-	-	-	-	-	-	1	3	1	-	5	5	8.00	0.71	8.00

7. RECOVERABLE (CONSUMABLE) STOCKAGE EFFECTIVENESS

** Criteria **	Participant Ratings 1	2	3	4	5	6	7	8	9	10	N	n	MN	STD	MD
Customer/Mission Focus	-	1	2	1	-	-	-	1	-	-	5	5	4.00	2.35	3.00
Continuous Process Impro	-	2	-	2	-	-	1	-	-	-	5	5	3.80	2.05	4.00

8. RECOVERABLE (CONSUMABLE) ISSUE EFFECTIVENESS

** Criteria **	Participant Ratings 1	2	3	4	5	6	7	8	9	10	N	n	MN	STD	MD
Customer/Mission Focus	-	1	2	1	-	-	-	1	-	-	5	5	4.00	2.35	3.00
Continuous Process Impro	-	2	1	1	-	-	1	-	-	-	5	5	3.60	1.85	3.00

9. RECEIPT-NOT-DUE-IN RATE

** Criteria **	Participant Ratings 1	2	3	4	5	6	7	8	9	10	N	n	MN	STD	MD
Customer/Mission Focus	-	1	2	2	-	-	-	-	-	-	5	5	3.20	0.84	3.00
Continuous Process Impro	-	1	-	-	2	-	1	-	-	1	5	5	5.80	2.95	5.00

10. PERCENT REPAIRABLE THIS STATION (OVERALL)

** Criteria **	Participant Ratings 1	2	3	4	5	6	7	8	9	10	N	n	MN	STD	MD
Customer/Mission Focus	-	1	1	-	2	-	-	1	-	-	5	5	4.60	2.30	5.00
Continuous Process Impro	1	1	-	-	1	1	-	-	1	-	5	5	4.60	3.21	5.00

11. INVENTORY ACCURACY (COMPLETED PLUS SPECIAL)

** Criteria **	Participant Ratings 1	2	3	4	5	6	7	8	9	10	N	n	MN	STD	MD
Customer/Mission Focus	-	1	-	1	-	-	2	-	-	1	5	5	6.00	3.08	7.00
Continuous Process Impro	-	-	1	-	-	1	-	2	1	-	5	5	6.80	2.39	8.00

12. RELEVELING FREQUENCY

** Criteria **	Participant Ratings 1	2	3	4	5	6	7	8	9	10	N	n	MN	STD	MD
Customer/Mission Focus	1	2	1	1	-	-	-	-	-	-	5	5	2.40	1.14	2.00
Continuous Process Impro	2	1	-	1	-	-	-	-	1	-	5	5	3.40	3.36	2.00

13. FOLLOW-UP FREQUENCY

** Criteria **	Participant Ratings 1	2	3	4	5	6	7	8	9	10	N	n	MN	STD	MD
Customer/Mission Focus	1	3	-	1	-	-	-	-	-	-	5	5	2.20	1.10	2.00
Continuous Process Impro	2	1	1	1	-	-	-	-	-	-	5	5	2.20	1.30	2.00

14. SERVICEABLE BALANCE WITH NO WAREHOUSE LOCATION

** Criteria **	Participant Ratings 1	2	3	4	5	6	7	8	9	10	N	n	MN	STD	MD
Customer/Mission Focus	-	2	-	-	2	1	-	-	-	-	5	5	4.00	1.87	5.00
Continuous Process Impro	-	-	1	1	-	1	2	-	-	-	5	5	5.40	1.82	6.00

15. ITEM RECORDS PAST DUE INVENTORY

** Criteria **	Participant Ratings 1	2	3	4	5	6	7	8	9	10	N	n	MN	STD	MD
Customer/Mission Focus	-	2	1	-	1	-	1	-	-	-	5	5	3.80	2.17	3.00
Continuous Process Impro	-	-	1	-	1	-	3	-	-	-	5	5	5.80	1.79	7.00

16. SYSTEM/GENERAL SUPPORT DIVISION (SSD & GSD) STOCKAGE EFFECTIVENESS

** Criteria **	Participant Ratings 1	2	3	4	5	6	7	8	9	10	N	n	MN	STD	MD
Customer/Mission Focus	-	1	1	2	-	1	-	-	-	-	5	5	3.80	1.48	4.00
Continuous Process Impro	-	3	-	1	-	1	-	-	-	-	5	5	3.20	1.79	2.00

17. SYSTEM/GENERAL SUPPORT DIVISION (SSD & GSD) ISSUE EFFECTIVENESS

** Criteria **	Participant Ratings 1	2	3	4	5	6	7	8	9	10	N	n	MN	STD	MD
Customer/Mission Focus	-	1	2	-	1	1	-	-	-	-	5	5	3.80	1.64	3.00
Continuous Process Impro	-	3	1	-	-	1	-	-	-	-	5	5	3.00	1.73	2.00

18. WAREHOUSE REFUSAL RATE

** Criteria **	Participant Ratings 1	2	3	4	5	6	7	8	9	10	N	n	MN	STD	MD
Customer/Mission Focus	-	-	-	-	1	-	-	1	2	1	5	5	8.20	1.92	9.00
Continuous Process Impro	-	-	-	-	-	-	1	3	-	1	5	5	8.20	1.10	8.00

>> Average ratings of all alternatives on each criterion <<

MN	STD	Criterion
5.20	1.99	How well does this indicator reflect customer/mission support?
5.10	1.83	How well does this indicator lead you to continually improve?

Criterion

HOW WELL DOES THIS INDICATOR REFLECT CUSTOMER/MISSION SUPPORT?

Ratings (MEAN)	Alternatives
8.20	**WAREHOUSE REFUSAL RATE**
8.00	**TOTAL NOT MISSION CAPABLE SUPPLY**
7.80	**STOCKAGE EFFECTIVENESS (PRIMARY WEAPON SYSTEM)**
7.20	**MISSION CAPABLE RATE**
7.20	ISSUE EFFECTIVENESS - (OVERALL)
6.80	BENCH STOCK AVAILABILITY
6.40	STOCKAGE EFFECTIVENESS - (OVERALL)
6.00	INVENTORY ACCURACY (COMPLETED PLUS SPECIAL)
4.60	PERCENT REPAIRABLE THIS STATION (OVERALL)
4.00	SERVICEABLE BALANCE WITH NO WAREHOUSE LOCATION
4.00	RECOVERABLE (CONSUMABLE) STOCKAGE EFFECTIVENESS
4.00	RECOVERABLE (CONSUMABLE) ISSUE EFFECTIVENESS
3.80	ITEM RECORDS PAST DUE INVENTORY
3.80	SYSTEM/GENERAL SUPPORT DIVISION (SSD & GSD) STOCKAGE EFFECTIVEN
3.80	SYSTEM/GENERAL SUPPORT DIVISION (SSD & GSD) ISSUE EFFECTIVENESS
3.20	RECEIPT-NOT-DUE-IN RATE
2.40	RELEVELING FREQUENCY
2.20	FOLLOW-UP FREQUENCY

Criterion

HOW WELL DOES THIS INDICATOR LEAD YOU TO CONTINUALLY IMPROVE THE PROCESS?

Ratings (MEAN)	Alternatives
8.20	**WAREHOUSE REFUSAL RATE**
8.00	**TOTAL NOT MISSION CAPABLE SUPPLY**
7.20	BENCH STOCK AVAILABILITY
6.80	STOCKAGE EFFECTIVENESS (PRIMARY WEAPON SYSTEM)
6.80	INVENTORY ACCURACY (COMPLETED PLUS SPECIAL)
5.80	MISSION CAPABLE RATE
5.80	ITEM RECORDS PAST DUE INVENTORY
5.80	RECEIPT-NOT-DUE-IN RATE
5.40	SERVICEABLE BALANCE WITH NO WAREHOUSE LOCATION
5.20	ISSUE EFFECTIVENESS - (OVERALL)
4.60	STOCKAGE EFFECTIVENESS - (OVERALL)
4.60	PERCENT REPAIRABLE THIS STATION (OVERALL)
3.80	RECOVERABLE (CONSUMABLE) STOCKAGE EFFECTIVENESS
3.60	RECOVERABLE (CONSUMABLE) ISSUE EFFECTIVENESS
3.40	RELEVELING FREQUENCY
3.20	SYSTEM/GENERAL SUPPORT DIVISION (SSD & GSD) STOCKAGE EFFECTIVEN
3.00	SYSTEM/GENERAL SUPPORT DIVISION (SSD & GSD) ISSUE EFFECTIVENESS
2.20	FOLLOW-UP FREQUENCY

Criterion

HOW WELL DOES THIS INDICATOR REFLECT CUSTOMER/MISSION SUPPORT?

Ratings (MEDIAN)	Alternatives
9.00	**WAREHOUSE REFUSAL RATE**
8.00	TOTAL NOT MISSION CAPABLE SUPPLY
8.00	STOCKAGE EFFECTIVENESS (PRIMARY WEAPON SYSTEM)
8.00	BENCH STOCK AVAILABILITY
7.00	MISSION CAPABLE RATE
7.00	ISSUE EFFECTIVENESS - (OVERALL)
7.00	STOCKAGE EFFECTIVENESS - (OVERALL)
7.00	INVENTORY ACCURACY (COMPLETED PLUS SPECIAL)
5.00	PERCENT REPAIRABLE THIS STATION (OVERALL)
5.00	SERVICEABLE BALANCE WITH NO WAREHOUSE LOCATION
4.00	SYSTEM/GENERAL SUPPORT DIVISION (SSD & GSD) STOCKAGE EFFECTIVEN
3.00	RECOVERABLE (CONSUMABLE) STOCKAGE EFFECTIVENESS
3.00	RECOVERABLE (CONSUMABLE) ISSUE EFFECTIVENESS
3.00	SYSTEM/GENERAL SUPPORT DIVISION (SSD & GSD) ISSUE EFFECTIVENESS
3.00	ITEM RECORDS PAST DUE INVENTORY
3.00	RECEIPT-NOT-DUE-IN RATE
2.00	RELEVELING FREQUENCY
2.00	FOLLOW-UP FREQUENCY

Criterion

HOW WELL DOES THIS INDICATOR LEAD YOU TO CONTINUALLY IMPROVE THE PROCESS?

Ratings (MEDIAN)	Alternatives
8.00	**WAREHOUSE REFUSAL RATE**
8.00	**TOTAL NOT MISSION CAPABLE SUPPLY**
7.00	**INVENTORY ACCURACY (COMPLETED PLUS SPECIAL)**
7.00	**BENCH STOCK AVAILABILITY**
7.00	ITEM RECORDS PAST DUE INVENTORY
6.00	STOCKAGE EFFECTIVENESS (PRIMARY WEAPON SYSTEM)
6.00	SERVICEABLE BALANCE WITH NO WAREHOUSE LOCATION
6.00	STOCKAGE EFFECTIVENESS - (OVERALL)
5.00	MISSION CAPABLE RATE
5.00	RECEIPT-NOT-DUE-IN RATE
5.00	ISSUE EFFECTIVENESS - (OVERALL)
5.00	PERCENT REPAIRABLE THIS STATION (OVERALL)
4.00	RECOVERABLE (CONSUMABLE) STOCKAGE EFFECTIVENESS
3.00	RECOVERABLE (CONSUMABLE) ISSUE EFFECTIVENESS
3.00	SYSTEM/GENERAL SUPPORT DIVISION (SSD & GSD) ISSUE EFFECTIVENESS
2.00	RELEVELING FREQUENCY
2.00	SYSTEM/GENERAL SUPPORT DIVISION (SSD & GSD) STOCKAGE EFFECTIVEN
2.00	FOLLOW-UP FREQUENCY

Appendix D: Revised Indicators

GENERAL INFORMATION

The revised supply management indicators presented to the second focus group are listed below along with the formulas used to equate the indicators.

#1 - **UNREPORTED EXCESS INVENTORY RATIO**

$$\frac{\$ \text{ Value of Unreported Excess Materiel}}{\text{Total } \$ \text{ Value of Inventory}}$$

#2 - **STOCKAGE EFFECTIVENESS** - (EACH WEAPON SYSTEM)

$$\frac{\text{No. WS Units Issued}}{\text{No. WS Units Issued} + \text{No. WS Units B/O} - \text{No. WS Units B/O 4W}}$$

#3 - **INVENTORY EFFECTIVENESS RATIO** - (OVERALL)

$$\text{Stockage Effectiveness } x \frac{\$ \text{ Value of On-hand Inventory}}{\$ \text{ Value of Authorized Inventory}}$$

#4 - **ISSUE EFFECTIVENESS** - (EACH WEAPON SYSTEM)

$$\frac{\text{No. WS Units Issued}}{\text{No. WS Units Issued} + \text{No. WS Units B/O}}$$

#5 - **NOT MISSION CAPABLE SUPPLY RATE**

$$\frac{\text{NMCS Hours}}{\text{Total Possessed Hours}}$$

#6 - **TOTAL NOT MISSION CAPABLE SUPPLY**

$$\frac{\text{NMCS + NMCB Hours}}{\text{Total Possessed Hours}}$$

#7 - **RECEIPT-NOT-DUE-IN RATE**

$$\frac{\textit{Total Shipments Received With No Corresponding Due-in}}{\textit{Total Number of Receipts}}$$

#8 - **PERCENT REPAIRABLE THIS STATION** (3-LEVEL MX ONLY)

$$\frac{\textit{Number 3 Level Maintenance Units Repairable This Station}}{\textit{No. 3LM Units RTS - No. 3LM Units NRTS - No. 3LM Units Cond}}$$

#9 - **INVENTORY ACCURACY** (COMPLETED PLUS SPECIAL)

$$1 - \frac{\textit{Total Units Over + Short}}{\textit{Total Record Balance}}$$

#10 - **SERVICEABLE BALANCE WITH NO WAREHOUSE LOCATION**

$$\frac{\textit{Numer of Item Records With Serv Bal and No Whse Location}}{\textit{Total Number of Item Records}}$$

#11 - **ITEM RECORDS FROZEN FOR INVENTORY RATE**

$$\frac{\textit{Item Records Frozen for Non-routine Inventory}}{\textit{Total Item Records}}$$

#12 - **TIME TO CLEAR FROZEN ITEM RECORDS**

Average Time to Clear Non-routine Frozen Item Records

#13 - **REVERSE POST RATE**

$$\frac{\textit{Number of Reverse Post Transactions}}{\textit{Total Number of Transactions}}$$

#14 - **WAREHOUSE REFUSAL RATE**

$$\frac{\textit{Total Number of Warehouse Refusals}}{\textit{Total Number of Issues}}$$

#15 - **BENCH STOCK AVAILABILITY** (BY ORGANIZATION)

$$\frac{\textit{Total Line Items Authorized - Line Items Due-out}}{\textit{Total Line Items Authorized}}$$

#16 - **NOT-STOCKED BACKORDER RATIO**

$$\frac{\textit{Number of Units Backordered 4W}}{\textit{Total Number of Units Backordered}}$$

#17 - **BENCH STOCK-MICAP RATE**

$$\frac{\textit{Number of MICAP Hours Due to Bench Stocked Items}}{\textit{Total Number of MICAP Hours}}$$

#18 - **SUPPLY CANN RATE**

$$\frac{\textit{Number of CANN Actions to Clear + Prevent MICAPs}}{\textit{Total Number of CANN Actions}}$$

Appendix E: Comments From Second Focus Group

1. UNREPORTED EXCESS INVENTORY RATIO

This would give a supply manager some feel for how reactive the computer(for automatic excess reporting) or the stock control section(for manual excess id and reporting) may be. Provides an opportunity to tweak either one.

This merely gives you an idea of what's waiting in the wings for disposal. If stratified in several different ways, it could offer a basis to discuss ordering habits with customers, but here would be touchy territory as supply finally got out of the "Policeman's" role it once had. Innovative supply guys could offer discount bargains to try and recoup some of the dollars invested. Any monies gained is better than none or incurring transportation costs to ship elsewhere.

Like the idea of a ratio. Measures results rather than activity.

I like the idea of looking at "unreported" excess, but we still need to be viewing excess which, although it may have been reported, is still on hand. We need to get a firm handle on excess which we have identified and reported, but which is still hanging around for whatever reason. (I recently read a report which "inadvertently" identified excess which had been reported but which had continued to sit in base supply for 12-18 months -- with no end in sight.) The report didn't seem to indicate a problem with this because "it had, in fact, been reported." However, I see this as a real problem because it's tying up needed dollars needed to run the account.

Any action to identify excess is a positive initiative. Millions of dollars of usable supply assets are hidden away in supply warehouses just waiting to be identified through the current system. Excesses continue to grow especially with the rapid changes to computers and software. By the time Supply builds up demand data, the current version is obsolete. Continue to make getting rid of excess easier.

2. STOCKAGE EFFECTIVENESS (EACH WEAPON SYSTEM)

This indicator is not necessarily a good tool for continuous improvement. However, it is vital information necessary to protect one's hind quarter.

At least this gives some visibility by WS. Total figure for the account is meaningless when trying to enhance a WS's support. Given the AF's stockage formulas, there isn't much mechanically that can be done to enhance the support. It will still be an intervention effort by stock controllers.

This measure tells how well the depots are supporting. At least one MAJCOM is stratifying this by weapon system and depot. Tells them where they need to concentrate their follow-up work.

Agree with above statements. "By weapon system" should be a much better indicator of not only the ability of the COS to support the WS, but also show where management emphasis is needed.

Good approach because it brings stockage effectiveness down to a more visible management tool. Helps identify which depot are really working to support their weapon system.

3. INVENTORY EFFECTIVENESS RATIO - (OVERALL)

I like this indicator expressed as a ratio. Gives the supply manager an opportunity to steer rather than row this ship.

I'd like to see a couple of different measures stratified with this.
1. stkage/issue effectiveness * ($ value of non-excess inventory/$ value of authorized inventory)
2. stkage/issue effectiveness * ($ value of reported and unreported excess inventory/$ value of authorized inventory).
REASON: How well is my non-excess working for me? How much does my excess hamper my effectiveness at providing what my customer needs?

Agree with comments on stratification. Need to define what behavior this would drive. If it doesn't drive a desired behavior, then it isn't an effective metric. I think this would drive the supply manager to increase stockage effectiveness, or increase on hand inventory, or decrease authorized inventory. Any one of those might be undesirable or desirable, depending on the circumstances.

Agree with stratification and whether or not this measure would be useful to the COS. I'm concerned about using ONLY dollar values. Some very high dollar value parts might skew the ratio and make the measure meaningless -- or at least less useful. I'm concerned that this might cause management

to take unnecessary action or the "wrong" action to correct something which may not be broken.

Based on the large dollar values involved with this measure, can a Supply squadron really impact this ratio. Some good gee whiz info but of limited value and may only generate over management because we,re not meeting the standard.

4. ISSUE EFFECTIVENESS - (EACH WEAPON SYSTEM)

So much of the decision regarding when to stock or how much to stock has become automated. Can this indicator provide an avenue for improvement or are we once again trying to protect ourselves. Nice to know, that's about all. If we could change the customer service level in the demand formula computations (to something other than the standard 84%) maybe this would be a tool for decision making.

Visibility by WS is valuable for those items which base supply is authorized stockage. Although I'm not sure what, if any, effect a retail supply account has on this, especially if not hand massaging the process. Does it really indicate a continuous improvement measure to control the process - NO!

I think this is a good indicator when viewed from the customer's point of view. He doesn't really care whether or not it's authorized for stock. If he needs it, he needs it! We tend to hide behind the "I'm not authorized to stock that" syndrome.

I think this is one which would be interesting to test in the field. With all the "complaints" in the earlier session about the usefulness or "un-usefulness" of issue effectiveness figures, the fact that this one is by WS, and also does not include authorized figures makes it intriguing. I think it's worth a shot. It could be dropped or altered later if found to be lacking.

This is a standard that Supply has dealt with for ever. With limited funding in the future and so many other organizations with the capability to bypass supply, this may not be a true way to evaluate supply. Keep it as a management tool.

5. NOT MISSION CAPABLE SUPPLY RATE

Great, you removed NMCB from the formula. Now, if we could differentiate transportation vs supply this indicator would

be awesome. As strides are made in providing full pipeline visibility (a goal in the two levels of maintenance project!) this differentiation may become a reality.

I think that this will be useful information to supply managers on how well MICAP is supporting the customer. Agree with other comment about segregation of other responsible activities/agencies for greater visibility since they are "suppliers" to our process of providing parts to our customer. Perhaps then, we could tighten the control limits and achieve REAL results.

Don't think this is useful. We used it for years and blamed maintenance for time they were working on the airplane, even though we still need the part. Doesn't drive any behavior to improve support. It does drive behavior to try to code time to maintenance and that doesn't get the part any faster. When we changed to TNMCS years ago it helped us take responsibility for ALL the time for which we owed maintenance a part. I think that was healthy.

I still think this is good for the COS ONLY. Unfortunately, it drives wings to "blame" different organizations for delays, etc. This is an indicator of "how things went," not a tool for "making things better."

This indicator is a blame them not me generator. Creates friction between Micap and Maintenance over what should be ordered Micap and what shouldn't. Still a good indicator for supply to show it really does play a big part in the wing's mission.

6. TOTAL NOT MISSION CAPABLE SUPPLY

Again, this is as good as it gets until total reparable pipeline visibility becomes a reality. Supply can make incremental improvements in this arena.

This didn't change, but I see it as a measure of cooperation between supply and its customer, maintenance. If we ever get to measuring prevention points in these processes, then we can strive to improve end products. As it currently is, this is an end of the process measure that detects, not prevents anything.

See comments on NMCS

This is a better indicator for use by the senior managers at a wing. The main thing lacking is something that can tell how much time is being consumed due to transportation or

funding problems. Again, I'm not too sure how much this number is going to help us make things better.

If your managing the NMCS rate you really don't need to worry about this one too

7. RECEIPT-NOT-DUE-IN RATE

I like this computed as a rate. The rate figure gives the supply manager a better indication of the relative size of this problem indicator.

As a rate, this lets supply know the magnitude of potential problems. Just numbers never did that. Combined with other data, such as where did the RNDIs in come from, meaningful analysis can be done. This can affect several areas of the account.

Agree with other comments. A rate is much more effective. It normalizes, for example, those months which have high activity.

Not to necessarily disagree with the others, I believe this rate will become more and more meaningLESS as time goes by. DRIVE and other new techniques for managing stock in the future (such as Lean Logistics/Just-In-Time, or whatever else you want to call it) are going to result in parts being pushed to the bases instead of us ordering them as we have in the past. This will result in an astronomical jump in the RNDI rate, but it will be good, not bad. These new methods of managing the AF inventory will make this measure obsolete and useless.

Supply is the recipient of this indicator with limited control on incoming property. Depot sends it and base supply receives it. Very little action is ever taken to do anything with this

8. PERCENT REPAIRABLE THIS STATION (3-LEVEL MX ONLY)

A matrix that the LG needs to be aware of. This is not necessarily a sound indicator for supply management improvement, but we have the capability to provide this data to someone who can better effect the results.

This could be useful data for MICAP research, stock control for adjusting stock levels, bench stock adjustments (items to support the reparables), etc. Since supply has the

capability to track, could be provided to the customer for his/her use.

Agree with other comments. Does data system let us differentiate between to and three level items now? If not, we will need to change select criteria for management reports.

Although this is not a meaningful measure of Supply activity or problems, it does give us a useful tool by which we can question Maintenance and help them in their ability to support the WS. I believe the MICAPers view this ability as helping to make them a more integral part of the Supply/Maintenance team.

Interesting management indicator but not a true supply indicator, give it to maintenance

9. INVENTORY ACCURACY (COMPLETED PLUS SPECIAL)

Inventory accuracy as a total picture (say monthly) does not provide an indicator for improvement. Because of the sheer volume, this indicator gets washed. To provide a clear picture, recommend this indicator be displayed by warehouse zones or sub-warehouses so that specific improvements could be targeted where required.

I have to agree with the comment about stratifying the data by warehouse, AND type of inventory accomplished. This would be more useful to the warehouse supervisor, inventory supervisor, the COS and managers in between. I suppose a roll-up, such as this, is necessary for a quick snapshot, but it doesn't help to pinpoint areas for improvement in procedures, training, security, etc. that more definitive data would.

Agree with foregoing comments. But what about an indicator called "initial inventory accuracy". The ALCs use that ratio to describe how accurate the inventory is upon initial request by the customer. It is computed using a 500 item sample once a quarter and measures items over or short as a ratio to total items BEFORE recounts and transaction research is done. Rationale for this is that the customer doesn't want to wait while we fix the record. If it's accurate from the start, he gets his part immediately. In the SBSS we might measure this as we go along in the annual complete inventory schedule rather than a sample.

Agree with all comments above. However, I believe that the "initial inventory accuracy" rate be computed AFTER the initial recount. i.e. the inventory person makes the count

and the initial check with the computer shows the count to be "over by 2 items". The inventory person then goes back and does a recount and discovers that a mistake in counting had been made during the initial count. This should not count against the reported accuracy rate. What we're looking for should be an accurate view of where we stand BEFORE automatic adjustments are made, but AFTER "dumb-shit" errors are discounted.

I use this indicator only by warehouse, overall total doesn't mean much

10. SERVICEABLE BALANCE WITH NO WAREHOUSE LOCATION

While $ value gives a more meaningful measure than just numbers of I/Rs, if stratifiable by weapons system, this could be really useful.

This is such rare event that it should be indicated by the actual number of serviceable balances with no location. When provided to the LGSD Supervisor, it can pinpoint training deficiencies or simply reaffirm the rare event. (statistically acceptable!)

Agree with other comments

I personally don't care for the use of $ value here. The low number of problems in this area offer the capability for the supply manager to find out if there might be problems in the warehousing process, but as I stated earlier, if $ values are the criteria, then one high dollar value item might equal 100 low dollar items. One mistake might not indicate a problem, whereas 100 probably would. If the dollar value of the one item equals the dollar value of the 100 items, we might never realize that a problem existed!

Not a big issue, but don't have any thing better to recommend

11. ITEM RECORDS FROZEN FOR INVENTORY RATE

I like this as a measure of items that are undergoing special inventory. Goal in any supply organization should be to keep specials down to a minimum. By making it a "ratio" you've leveled the playing field between large and small organizations.

I like this expressed as a ratio!

Ratio much better than numbers for trend analysis and comparisons, but knowledge of the individual incidents is also required for first level supervisor action.

Go for it.

Disagree with some comments. I would rather see the numbers rather than a ratio. The ratio should always be 99 percent, numbers tell you when, where, and why problems exist

12. TIME TO CLEAR FROZEN ITEM RECORDS

I like this, too. It goes hand-in-glove with #11. If the measure self-stratifies (ages) into days (1,2,3,4,>5) would also be valuable to managers in determining responsiveness to special occurrences within the account (i.e. a possible measure of customer responsiveness). If once programmed to be collected, then managers could get a special run by W/S if desired.

This indicator provides good efficiency data. How rapid do my inventory folks resolve discrepancies? I would not want many items to sit unattended very long.

Agree with other comments. This is a useful addition to the family of metrics for supply. We always watched this at accounts where I was assigned.

This one looks like it's going to be a real winner! It might be useful to somehow be able to identify these items by warehouse number so that it would be easier to identify where problem areas may be developing.

Good indicator. Keep this one

13. REVERSE POST RATE

As always, the goal is zero. But this provides an order of magnitude based on account activity in lieu of just the number of reverse posts that took place.

Expressed as a rate, this indicator is now improved.

Much better as a rate.

I like it better as a rate, but I would also like to be able to have the ability to distinguish the rate by transaction type. I'm sure this could be developed at the base, but I

just think it would be good to better identify where the problems are really located.

Concur with other comments, this can open a bucket of worms when used for analysis purposes

14. WAREHOUSE REFUSAL RATE

Here again, goal is zero, but the order of magnitude is a better indicator. Often took the numbers and computed a rate before - perspective was much clearer.

Rate computation gives manager a basis of magnitude. Great!

Better as a rate. Suggest stratification by warehouse to pinpoint where the problems are.

Good. Now we need to see WHICH warehouses are having the problems. Same comments, basically, as for Reverse Post Rate.

This figure/rate should be small but should be tracked to keep the warehouse on a positive role

15. BENCH STOCK AVAILABILITY (BY ORGANIZATION)

By organization, surely gives a much clearer picture of support to the individual customer. In this day of "customer satisfaction" this gives us a singular point-in-time picture. What it doesn't convey are those items that for funding constraints haven't been ordered; those items which are first time adds to the customer's bench stock. These special conditions are known only through separate knowledge and documentation.

Expressed by organization, this indicator provides for continuous and specific customer service gains.

Agree with foregoing.

Agree with above, but I believe in most cases, the COS is not going to have many items not ordered due to lack of funds since most of the bench stock stuff are low dollar items.

Good indicator by organization

16. NOT-STOCKED BACKORDER RATIO

With this I can segregate those items over which I have some control from those which I have absolutely zero control (4Ws). For new weapons systems being brought on-line this would be extremely meaningful. I would think that the Chief of Maintenance would also find this useful information.

Marry this indicator with the stockage effectiveness indicator. Shown side-by-side this provides specific insight you can share with your customers in pursuit of closer customer relations.

Agree with foregoing comments.

I don't have any problems with this on paper. I would love to see it in use to determine if it needs to be tweaked some more.

I like this one. Hopefully it will show the customer that they are buying things Supply doesn't stock

17. BENCH STOCK-MICAP RATE

YES! YES! YES! Too many times close to fiscal year end, we cut back on bench stock fill to control expenditures. This would give all concerned a measure that could be used to beef up stock on certain NSNs, to preclude the costly MICAPs. For want of a bench stock item, the mission wasn't flown - what a sad and unnecessary thing to occur.

Good Stuff! Why let small dollar value items ground systems or aircraft. The LG might want to talk to the maintenance bench stock folks(for failing to fill B/S) or the supply folks(for not having the restock assets when required.

Good way to zero in on problems caused by small items. I think most of these have been lead time or procurement problems in the past, but with SSD obligation authority restrictions we're now experiencing, the funding issue will become the most important in the future.

I REALLY LIKE THIS ONE! Should be very useful in showing how the bench stock items are affecting mission support.

Not sure this will prove to be useful, but it should be implemented on a test basis to see what develops

18. SUPPLY CANN RATE (BY WEAPON SYSTEM)

In an effort to improve customer service, this indicator says a lot. How much work is supply forcing on maint. for lack of asset? Is the item critically short everywhere? (Item manager, where are you?) (HQ, What are you doing?)

Don't think that this is available in supply's database. Would be obtained from Maintenance, right? Not sure that base supply can have significant impact to improve the stockage effectiveness to lower this rate. However, it would provide data for supply to use in "negotiations" with Item Managers and HQs staffs that monkey around with the UMMIPS priority system to achieve hidden agendas (good rates for one base vs another; level # down aircraft among bases; retain stocks for really high priorities, etc.)

Not new. Most accounts have tracked this for years. It is a good indicator of how much work the supply system is causing maintenance. What behavior does it drive? Does it make supply work harder to get parts on the shelf? Takes some leadership to make the connection to the troops. This is a powerful metric in the hands of perceptive leadership.

Very good comments above. This measure is better used locally by knowledgeable managers as opposed to command-wide comparisons. The reason for this is that there are differing views on how and when canns should and will be used at different wings. All elements being equal, some wings will cann a part while others will not -- all for good but different reasons. Thus, a higher cann rate for one wing may not mean that Supply is doing a worse job in supporting maintenance than another with a lower cann rate. Taken in-house, though, and measured over time, this measure can show meaningful trends.

I like this indicator because it gets Supply and Maintenance talking together to solve a common problem

Appendix F: Ratings From Second Focus Group

>> Equally Weighted Criteria (Text Report) <<

Median	Mean	** ALTERNATIVES **
18	17.2	BENCH STOCK-MICAP RATE
18	16.6	BENCH STOCK AVAILABILITY (BY ORGANIZATION)
16	15.8	TIME TO CLEAR FROZEN ITEM RECORDS
16	15.2	SUPPLY CANN RATE (BY WEAPON SYSTEM)
15	14.4	STOCKAGE EFFECTIVENESS (EACH WEAPON SYSTEM)
15	14.0	ISSUE EFFECTIVENESS - (EACH WEAPON SYSTEM)
15	13.8	NOT MISSION CAPABLE SUPPLY RATE
15	13.6	WAREHOUSE REFUSAL RATE
14	14.4	ITEM RECORDS FROZEN FOR INVENTORY RATE
14	13.2	REVERSE POST RATE
14	12.6	TOTAL NOT MISSION CAPABLE SUPPLY
12	12.2	NOT-STOCKED BACKORDER RATIO
12	11.8	INVENTORY EFFECTIVENESS RATIO - (OVERALL)
12	10.6	UNREPORTED EXCESS INVENTORY RATIO
11	12.0	PERCENT REPAIRABLE THIS STATION (3-LEVEL MX ONLY)
11	10.8	INVENTORY ACCURACY (COMPLETED PLUS SPECIAL)
9	9.8	RECEIPT-NOT-DUE-IN RATE
9	9.2	SERVICEABLE BALANCE WITH NO WAREHOUSE LOCATION

>> Criteria Matrix <<

1. How well does this indicator reflect customer/mission support?

** Alternative **	Participant Ratings 1	2	3	4	5	6	7	8	9	10	N	n	MN	STD	MED
UNREPORTED EXCESS IN	-	-	2	-	1	2	-	-	-	-	5	5	4.6	1.53	5
STOCKAGE EFFECTIVENE	-	-	-	-	-	-	1	4	-	-	5	5	7.8	0.40	8
INVENTORY EFFECTIVEN	-	-	-	1	1	2	-	-	1	-	5	5	6.0	1.67	6
ISSUE EFFECTIVENESS	-	-	-	-	1	-	1	1	2	-	5	5	7.6	1.50	8
NOT MISSION CAPABLE	-	-	1	-	1	-	1	1	1	-	5	5	7.0	1.67	7
TOTAL NOT MISSION CA	-	-	-	-	2	-	2	-	1	-	5	5	6.6	1.50	7
RECEIPT-NOT-DUE-IN R	-	1	1	1	1	-	1	-	-	-	5	5	4.2	1.72	4
PERCENT REPAIRABLE T	-	1	-	-	2	-	1	1	-	-	5	5	5.4	2.06	5
INVENTORY ACCURACY (	-	1	-	2	-	1	1	-	-	-	5	5	4.6	1.74	4
SERVICEABLE BALANCE	-	2	1	-	1	1	-	-	-	-	5	5	3.6	1.62	3
ITEM RECORDS FROZEN	-	-	-	-	1	2	1	1	-	-	5	5	6.4	1.02	6
TIME TO CLEAR FROZEN	-	-	-	-	-	-	3	1	1	-	5	5	7.6	0.80	7
REVERSE POST RATE	-	-	-	-	2	2	1	-	-	-	5	5	5.8	0.75	6
WAREHOUSE REFUSAL RA	-	-	-	1	-	-	2	1	1	-	5	5	7.0	1.67	7
BENCH STOCK AVAILABL	-	-	-	-	-	-	1	1	3	-	5	5	8.4	0.80	9
NOT-STOCKED BACKORDE	-	-	-	-	1	3	1	-	-	-	5	5	6.0	0.63	6
BENCH STOCK-MICAP RA	-	-	-	-	-	1	-	-	2	2	5	5	8.8	1.47	9
SUPPLY CANN RATE (BY	-	-	-	-	-	1	1	2	1	-	5	5	7.6	1.02	8

2. How well does this indicator lead you to continually improve the process

** Alternative **	Participant Ratings 1	2	3	4	5	6	7	8	9	10	N	n	MN	STD	MED
UNREPORTED EXCESS IN	-	-	-	1	1	-	2	1	-	-	5	5	6.0	1.41	7
STOCKAGE EFFECTIVENE	-	-	-	-	1	1	2	1	-	-	5	5	6.6	1.02	7
INVENTORY EFFECTIVEN	-	-	-	1	-	3	1	-	-	-	5	5	5.8	0.98	6
ISSUE EFFECTIVENESS	-	1	-	-	-	-	2	2	-	-	5	5	6.4	2.24	7
NOT MISSION CAPABLE	-	-	-	1	-	1	-	3	-	-	5	5	6.8	1.60	8
TOTAL NOT MISSION CA	-	1	-	-	1	-	2	-	1	-	5	5	6.0	2.37	7
RECEIPT-NOT-DUE-IN R	-	-	1	1	1	-	-	2	-	-	5	5	5.6	2.06	5
PERCENT REPAIRABLE T	-	-	-	-	1	2	1	-	1	-	5	5	6.6	1.36	6
INVENTORY ACCURACY (	1	-	-	-	-	-	3	-	1	-	5	5	6.2	2.71	7
SERVICEABLE BALANCE	-	1	-	-	1	1	1	1	-	-	5	5	5.6	2.06	6
ITEM RECORDS FROZEN	-	-	-	-	-	1	-	3	-	1	5	5	8.0	1.26	8
TIME TO CLEAR FROZEN	-	-	-	-	1	-	-	1	2	1	5	5	8.2	1.72	9
REVERSE POST RATE	-	-	-	-	1	-	1	2	1	-	5	5	7.4	1.36	8
WAREHOUSE REFUSAL RA	-	-	-	-	1	1	-	2	1	-	5	5	7.2	1.47	8
BENCH STOCK AVAILABL	-	-	-	-	-	1	-	1	3	-	5	5	8.2	1.16	9
NOT-STOCKED BACKORDE	-	-	-	1	-	2	1	1	-	-	5	5	6.2	1.32	6
BENCH STOCK-MICAP RA	-	-	-	-	-	-	1	1	3	-	5	5	8.4	0.80	9
SUPPLY CANN RATE (BY	-	-	-	-	-	1	-	4	-	-	5	5	7.6	0.80	8

Appendix G: Supply Management Indicator Questionnaire

INSTRUCTIONS

The purpose of this research is to try to develop supply management indicators that are more in line with the TQM philosophy. Specifically, to find useful measures (metrics) that display the TQM concepts of customer focus and continuous process improvement.

The attached 18 indicators were developed through extensive research on measurement and TQM. They are indicators which the research implies are better management tools than many currently used supply indicators and can be used to compare dissimilar operations.

Please rate the following indicators on a scale of 1 (low) to 10 (high) on two criteria.
The first criteria is:

How well does this indicator reflect customer/mission support?

The second criteria is:

How well will this indicator lead you to continually improve the process?

Each indicator should be rated on its own merit, not relative to the other indicators. In other words, it is possible that they can all be tens or they can all be twos. Also, just because an indicator rates high on one criteria does not necessarily mean that it will rate as high on the other.

Feel free to make any comments concerning these indicators in the space provided. Please return the completed appraisal in the enclosed envelope.

Thank you for your assistance.

Brian B. Yoo, Capt, USAF Michael O. Cannon, 1Lt, USAF

#1 - **UNREPORTED EXCESS INVENTORY RATIO**

$$\frac{\$ \text{ Value of Unreported Excess Materiel}}{\text{Total } \$ \text{ Value of Inventory}}$$

Customer/Mission Focus	1	2	3	4	5	6	7	8	9	10
Continuous Improvement	1	2	3	4	5	6	7	8	9	10

COMMENTS: _____

_____

_____

_____

#2 - **STOCKAGE EFFECTIVENESS** - (EACH WEAPON SYSTEM)

$$\frac{\text{No. WS Units Issued}}{\text{No. WS Units Issued} + \text{No. WS Units B/O} - \text{No. WS Units B/O 4W}}$$

Customer/Mission Focus	1	2	3	4	5	6	7	8	9	10
Continuous Improvement	1	2	3	4	5	6	7	8	9	10

COMMENTS: _____

_____

_____

_____

#3 - **INVENTORY EFFECTIVENESS RATIO** - (OVERALL)

$$\text{Stockage Effectiveness} \times \frac{\$ \text{ Value of On-hand Inventory}}{\$ \text{ Value of Authorized Inventory}}$$

Customer/Mission Focus	1	2	3	4	5	6	7	8	9	10
Continuous Improvement	1	2	3	4	5	6	7	8	9	10

COMMENTS: _____

_____

_____

_____

#4 - **ISSUE EFFECTIVENESS** - (EACH WEAPON SYSTEM)

$$\frac{\textit{No. WS Units Issued}}{\textit{No. WS Units Issued + No. WS Units B/O}}$$

Customer/Mission Focus	1	2	3	4	5	6	7	8	9	10
Continuous Improvement	1	2	3	4	5	6	7	8	9	10

COMMENTS: _____

_____

_____

_____

#5 - **NOT MISSION CAPABLE SUPPLY RATE**

$$\frac{\textit{NMCS Hours}}{\textit{Total Possessed Hours}}$$

Customer/Mission Focus	1	2	3	4	5	6	7	8	9	10
Continuous Improvement	1	2	3	4	5	6	7	8	9	10

COMMENTS: _____

_____

_____

_____

#6 - **TOTAL NOT MISSION CAPABLE SUPPLY**

$$\frac{\textit{NMCS + NMCB Hours}}{\textit{Total Possessed Hours}}$$

Customer/Mission Focus	1	2	3	4	5	6	7	8	9	10
Continuous Improvement	1	2	3	4	5	6	7	8	9	10

COMMENTS: _____

_____

_____

_____

#7 - **RECEIPT-NOT-DUE-IN RATE**

$$\frac{\textit{Total Shipments Received With No Corresponding Due-in}}{\textit{Total Number of Receipts}}$$

Customer/Mission Focus	1	2	3	4	5	6	7	8	9	10
Continuous Improvement	1	2	3	4	5	6	7	8	9	10

COMMENTS: _____

_____

_____

_____

#8 - **PERCENT REPAIRABLE THIS STATION** (3-LEVEL MX ONLY)

$$\frac{\textit{Number 3 Level Maintenance Units Repairable This Station}}{\textit{No. 3LM Units RTS - No. 3LM Units NRTS - No. 3LM Units Cond}}$$

Customer/Mission Focus	1	2	3	4	5	6	7	8	9	10
Continuous Improvement	1	2	3	4	5	6	7	8	9	10

COMMENTS: _____

_____

_____

_____

#9 - **INVENTORY ACCURACY** (COMPLETED PLUS SPECIAL)

$$1 - \frac{\textit{Total Units Over + Short}}{\textit{Total Record Balance}}$$

Customer/Mission Focus	1	2	3	4	5	6	7	8	9	10
Continuous Improvement	1	2	3	4	5	6	7	8	9	10

COMMENTS: _____

_____

_____

_____

#10 - **SERVICEABLE BALANCE WITH NO WAREHOUSE LOCATION**

$$\frac{\$ \text{ Value of Item Records With Serv Bal and No Whse Location}}{\text{Total \$ Value of Inventory}}$$

Customer/Mission Focus	1	2	3	4	5	6	7	8	9	10
Continuous Improvement	1	2	3	4	5	6	7	8	9	10

COMMENTS: _____

_____

_____

_____

#11 - **ITEM RECORDS FROZEN FOR INVENTORY RATE**

$$\frac{\text{Item Records Frozen for Non-routine Inventory}}{\text{Total Item Records}}$$

Customer/Mission Focus	1	2	3	4	5	6	7	8	9	10
Continuous Improvement	1	2	3	4	5	6	7	8	9	10

COMMENTS: _____

_____

_____

_____

#12 - **TIME TO CLEAR FROZEN ITEM RECORDS**

Average Time to Clear Non-routine Frozen Item Records

Customer/Mission Focus	1	2	3	4	5	6	7	8	9	10
Continuous Improvement	1	2	3	4	5	6	7	8	9	10

COMMENTS: _____

_____

_____

_____

#13 - **REVERSE POST RATE**

$$\frac{\textit{Number of Reverse Post Transactions}}{\textit{Total Number of Transactions}}$$

Customer/Mission Focus	1	2	3	4	5	6	7	8	9	10
Continuous Improvement	1	2	3	4	5	6	7	8	9	10

COMMENTS: _____

_____

_____

_____

#14 - **WAREHOUSE REFUSAL RATE**

$$\frac{\textit{Total Number of Warehouse Refusals}}{\textit{Total Number of Issues}}$$

Customer/Mission Focus	1	2	3	4	5	6	7	8	9	10
Continuous Improvement	1	2	3	4	5	6	7	8	9	10

COMMENTS: _____

_____

_____

_____

#15 - **BENCH STOCK AVAILABILITY** (BY ORGANIZATION)

$$\frac{\textit{Total Line Items Authorized - Line Items Due-out}}{\textit{Total Line Items Authorized}}$$

Customer/Mission Focus	1	2	3	4	5	6	7	8	9	10
Continuous Improvement	1	2	3	4	5	6	7	8	9	10

COMMENTS: _____

_____

_____

_____

#16 - **NOT-STOCKED BACKORDER RATIO**

$$\frac{\textit{Number of Units Backordered 4W}}{\textit{Total Number of Units Backordered}}$$

Customer/Mission Focus	1	2	3	4	5	6	7	8	9	10
Continuous Improvement	1	2	3	4	5	6	7	8	9	10

COMMENTS: _____

_____

_____

_____

#17 - **BENCH STOCK-MICAP RATE**

$$\frac{\textit{Number of MICAP Hours Due to Bench Stocked Items}}{\textit{Total Number of MICAP Hours}}$$

Customer/Mission Focus	1	2	3	4	5	6	7	8	9	10
Continuous Improvement	1	2	3	4	5	6	7	8	9	10

COMMENTS: _____

_____

_____

_____

#18 - **SUPPLY CANN RATE**

$$\frac{\textit{Number of CANN Actions to Clear + Prevent MICAPs}}{\textit{Total Number of CANN Actions}}$$

Customer/Mission Focus	1	2	3	4	5	6	7	8	9	10
Continuous Improvement	1	2	3	4	5	6	7	8	9	10

COMMENTS: _____

_____

_____

_____

Appendix H: Ratings From Questionnaire

>> Equally Weighted Criteria (Text Report) <<

Median	Mean	** ALTERNATIVES **
19	17.5	NOT MISSION CAPABLE SUPPLY RATE
18	17.3	BENCH STOCK AVAILABILITY (BY ORGANIZATION)
18	17.1	STOCKAGE EFFECTIVENESS (EACH WEAPON SYSTEM)
18	16.8	BENCH STOCK-MICAP RATE
17	16.9	TOTAL NOT MISSION CAPABLE SUPPLY
17	16.0	INVENTORY ACCURACY (COMPLETED PLUS SPECIAL)
17	15.9	SERVICEABLE BALANCE WITH NO WAREHOUSE LOCATION
16	15.9	WAREHOUSE REFUSAL RATE
16	15.7	SUPPLY CANN RATE (BY WEAPON SYSTEM)
16	15.6	ISSUE EFFECTIVENESS - (EACH WEAPON SYSTEM)
16	14.3	PERCENT REPAIRABLE THIS STATION (3-LEVEL MX ONLY)
15	14.2	REVERSE POST RATE
14.5	14.1	TIME TO CLEAR FROZEN ITEM RECORDS
14	13.9	RECEIPT-NOT-DUE-IN RATE
14	12.7	UNREPORTED EXCESS INVENTORY RATIO
14	12.2	NOT-STOCKED BACKORDER RATIO
13	12.7	ITEM RECORDS FROZEN FOR INVENTORY RATE
12	11.9	INVENTORY EFFECTIVENESS RATIO - (OVERALL)

>> Criteria Matrix <<

1. How well does this indicator reflect customer/mission support?

** Alternative **	Participant Ratings 1	2	3	4	5	6	7	8	9	10	N	n	MN	STD	MED
UNREPORTED EXCESS IN	4	1	2	2	1	2	4	3	-	2	21	21	5.2	2.98	6
STOCKAGE EFFECTIVENE	-	-	1	-	-	1	2	3	7	7	21	21	8.6	1.72	9
INVENTORY EFFECTIVEN	2	-	4	3	1	-	4	-	3	2	21	19	5.6	2.97	5
ISSUE EFFECTIVENESS	-	1	-	1	-	3	1	5	3	7	21	21	8.0	2.19	8
NOT MISSION CAPABLE	-	-	-	-	1	1	2	2	4	11	21	21	8.9	1.51	10
TOTAL NOT MISSION CA	-	-	-	-	1	2	2	2	5	8	21	20	8.6	1.60	9
RECEIPT-NOT-DUE-IN R	1	2	2	2	2	2	5	1	3	1	21	21	5.8	2.61	6
PERCENT REPAIRABLE T	-	1	2	-	1	2	3	5	2	5	21	21	7.3	2.44	8
INVENTORY ACCURACY	-	2	-	1	1	1	5	2	6	3	21	21	7.3	2.39	8
SERVICEABLE BALANCE	-	1	1	-	3	1	3	4	6	2	21	21	7.3	2.22	8
ITEM RECORDS FROZEN	-	1	3	2	5	3	1	3	2	1	21	21	5.8	2.26	5
TIME TO CLEAR FROZEN	-	-	1	2	4	3	2	6	1	2	21	21	6.7	1.98	7
REVERSE POST RATE	-	-	4	1	4	1	4	3	3	1	21	21	6.2	2.26	7
WAREHOUSE REFUSAL RA	-	-	-	1	-	4	3	5	4	4	21	21	7.9	1.65	8
BENCH STOCK AVAILABL	-	-	-	-	-	1	1	4	10	5	21	21	8.8	1.03	9
NOT-STOCKED BACKORDE	1	1	-	1	3	3	6	4	1	1	21	21	6.3	2.15	7
BENCH STOCK-MICAP RA	-	-	1	-	-	1	2	2	10	5	21	21	8.5	1.66	9
SUPP CANN RATE (BY	-	1	1	-	-	-	5	4	5	4	21	20	7.9	2.13	8

2. How well does this indicator lead you to continually improve the process

** Alternative **	Participant Ratings 1	2	3	4	5	6	7	8	9	10	N	n	MN	STD	MED
UNREPORTED EXCESS IN	-	-	1	-	1	3	5	5	3	3	21	21	7.5	1.75	8
STOCKAGE EFFECTIVENE	-	-	-	-	1	1	2	4	6	7	21	21	8.6	1.43	9
INVENTORY EFFECTIVEN	2	-	2	2	1	-	5	1	3	3	21	19	6.4	2.97	7
ISSUE EFFECTIVENESS	1	1	-	1	-	2	2	5	4	5	21	21	7.6	2.56	8
NOT MISSION CAPABLE	-	-	-	-	1	-	3	6	3	8	21	21	8.6	1.40	9
TOTAL NOT MISSION CA	-	-	-	-	1	2	2	6	3	6	21	20	8.3	1.53	8
RECEIPT-NOT-DUE-IN R	-	-	-	-	1	2	2	8	5	3	21	21	8.1	1.34	8
PERCENT REPAIRABLE T	1	3	-	-	1	1	3	4	5	3	21	21	7.0	2.89	8
INVENTORY ACCURACY	-	-	1	-	-	-	-	5	12	3	21	21	8.6	1.43	9
SERVICEABLE BALANCE	-	-	-	-	-	-	2	8	7	4	21	21	8.6	0.92	9
ITEM RECORDS FROZEN	-	1	1	1	1	4	1	8	3	1	21	21	7.0	2.09	8
TIME TO CLEAR FROZEN	-	-	1	-	1	5	1	8	2	3	21	21	7.5	1.78	8
REVERSE POST RATE	-	-	-	1	2	-	3	5	7	3	21	21	8.0	1.67	8
WAREHOUSE REFUSAL RA	-	-	-	1	-	1	6	5	2	6	21	21	8.1	1.61	8
BENCH STOCK AVAILABL	-	-	-	1	-	1	1	7	4	7	21	21	8.5	1.54	9
NOT-STOCKED BACKORDE	2	1	1	-	3	3	6	4	1	-	21	21	5.9	2.33	7
BENCH STOCK-MICAP RA	-	-	1	-	2	-	2	2	8	6	21	21	8.3	1.93	9
SUPPLY CANN RATE (BY	-	-	1	-	1	1	3	7	4	3	21	20	7.9	1.73	8

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Vita

First Lieutenant Michael O. Cannon was born on 6 January, 1963 in San Bernadino, California. He graduated from Quincy Junior-Senior High School in 1981 and enlisted in the Air Force as an Aircrew Life Support Specialist. He received a Bachelor of Arts from Eastern Illinois University in 1988 and was commissioned through the Officer Training School, Lackland AFB, Texas in 1989. Upon commissioning, he was assigned as the Chief of Materiel Management Branch, 14th Supply Squadron, Columbus AFB, Mississippi. He later served as the Operations Support Flight Commander and OIC of Base Contracting. He is married to the former Elizabeth M. Livingston of Spokane, Washington and they have two children; Christopher Michael, age 3, and Karen Marie, age 1. He entered the School of Logistics and Acquisition Management, Air Force Institute of Technology, in May 1992. His follow-on assignment will be as a Supply Operations Officer with the 633d Supply Squadron, Andersen AFB, Guam.

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Vita

Captain Brian B. Yoo was born on 17 March 1966 in Inchon, Republic of Korea. He immigrated to the United States at the age of eight and graduated from John Marshall High School in Los Angeles in 1984. He graduated from the U. S. Air Force Academy on 1 June 1988 with a Bachelor of Science degree. His first assignment was to the 22nd Supply Squadron, March AFB, California where he started out as the Chief of Tanker Support Section and later became the Fuels Management Officer. From May 1991 to May 1992, he was assigned to the 8th Supply Squadron, Kunsan AB, Republic of Korea where he held the position of Materiel Management Officer. He entered the School of Logistics and Acquisition Management of the Air Force Institute of Technology in May 1992.

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13. ABSTRACT (*Maximum 200 words*)

The purpose of this thesis was to determine if current supply management indicators provide supply managers with quality measurement tools. This research developed the Quality-Based Metrics Framework, consisting of customer focus and continuous process improvement with underlying supporting elements of time and cost. A literature review determined an appropriate framework for improving logistics indicators. Interviews with supply analysts and a review of pertinent publications identified the most commonly used supply management indicators. A focus group of highly experienced senior supply officers determined the usefulness of currently used indicators in terms of the framework. Using the input from the focus group, the authors developed a revised list of metrics which strongly reflected the elements of the framework. The revised metrics were evaluated by the same focus group and found to be more useful in terms of the framework. These results were validated by surveying a sample of senior supply managers throughout the Air Force. The results indicate that the current supply indicators could be improved to provide managers with better quality management tools.

14. SUBJECT TERMS

Supply Indicators, Metrics, Measures, Continuous Improvement, Customer Focus

15. NUMBER OF PAGES

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16. PRICE CODE

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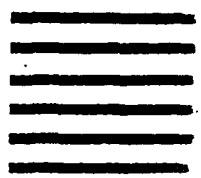

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